19<sup>th</sup> International Scientific and Technical Conference **FROM IMAGERY TO DIGITAL REALITY:** ERS & Photogrammetry



PHOTOMOD Radar — a powerful tool for processing of SAR images Alexander Chekurin Sales & Marketing Director Racurs Russia

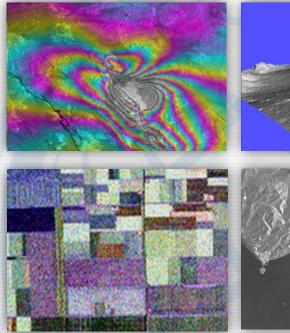
October 28-31, 2019 Seoul, Republic of Korea

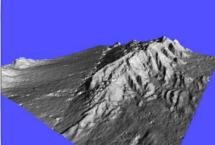


# **Radar imagery applications**

- 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



Software solutions in the field of photogrammetry, GIS and remote sensing +7 495 720 51 27 | info@racurs.ru | racurs.ru

祭

9

\*

# **Basic knowledge**

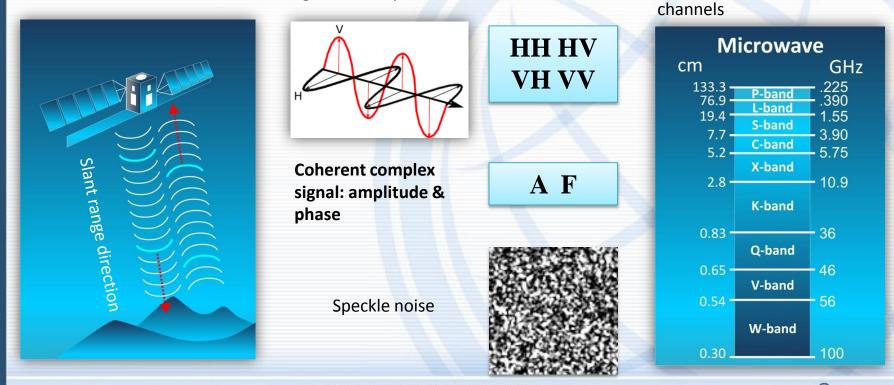
### Specific nature of SAR data processing vs optical remote sensing:

One or more frequency

RACURS

Slant range projection

Single or multi polarization mode



Software solutions in the field of photogrammetry, GIS and remote sensing +7 495 720 51 27 | info@racurs.ru | racurs.ru

粥

6

**S** 

-

\*

# **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

RACURS

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

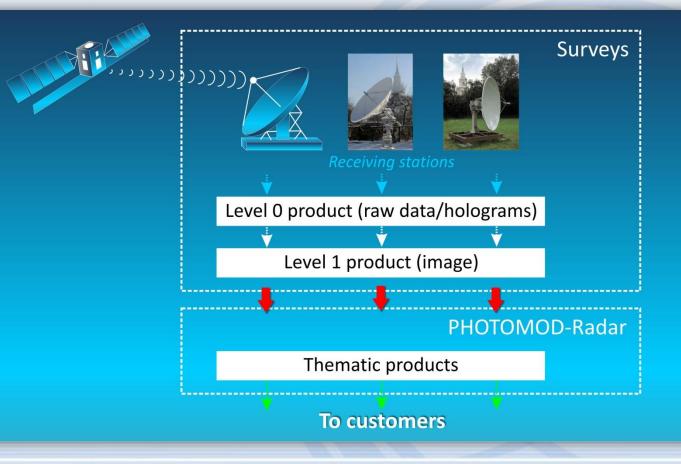
A PHOTOMOD-Radar									
<u>M</u> ain	<u>U</u> tilities	E <u>n</u> hancement	<u>F</u> eatures ALMAZ-1	Georeferencing	Radargrammetry	Quality Marine	Options <u>H</u> elp		
Main	Tools	<u>G</u> eneral Utilities	I <u>m</u> age Enhancement	Eeatures Extraction	ALMAZ-1 Processing	Georeferencing utilities	Radargrammetry Applications	Quality Estimation	Marine Applications
<u>V</u> iew	er		Import / Exit Export						

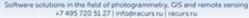
祭

9

翁

### SAR data processing chain





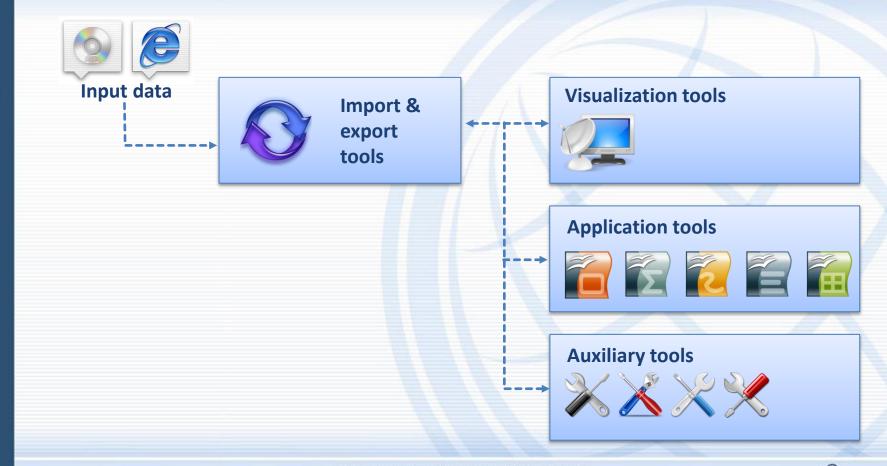


粥

1

\*

### **PHOTOMOD** Radar structure



RACURS

黎

6

Se

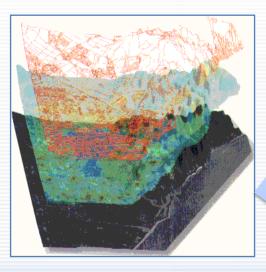
-

\*

### **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





黎

6

-

1

\*

 $(\mathbf{O})$ 

### **Supported sensors**



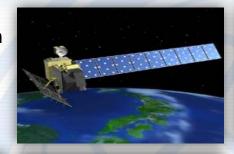
Almaz-1ERS-1/2

- JERS-1
- SIR-C/X

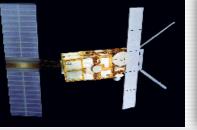
RADARSAT-1,2

**ENVISAT** 

- ALOS PALSAR
- TerraSAR-X/Tandem
- COSMO-SkyMed
- Kompsat-5
  - Sentinel-1
- Risat















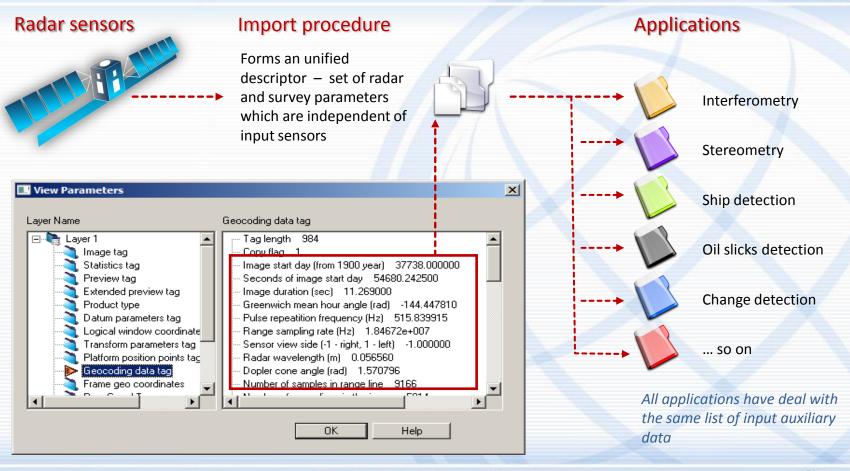




RACURS

Software solutions in the field of photogrammetry, GIS and remote sensing +7 495 720 51 27 | info@racurs.ru | racurs.ru

### **Concept of generalized radar model**



RACURS

黎

1

\*

### Import module



Software solutions in the field of photogrammetry, GIS and remote sensing +7 495 720 51 27 | info@racurs.ru | racurs.ru

RACURS

黎

-

50

## **Visualization tools**

#### SAR sensor data visualization tools:

2D viewer 🔳 3D viewer



RACURS

粥

6

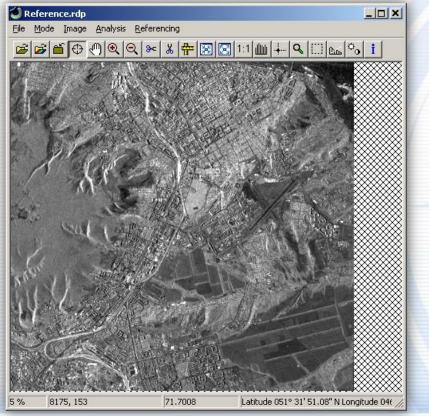
3

1

\*

## **Visualization tools**

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





RACURS

零

6

-

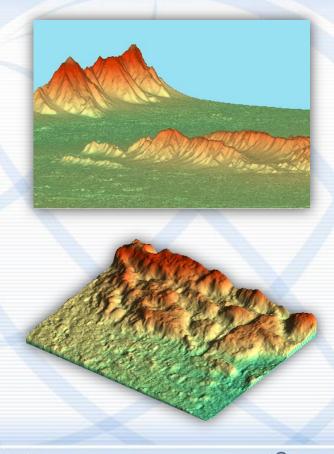
\*

 $( \bigcirc )$ 

# **Visualization tools**

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

3D Viewer         File Mode Image Analysis         I		
50% 411, 401	140.182	14



RACURS

% \*

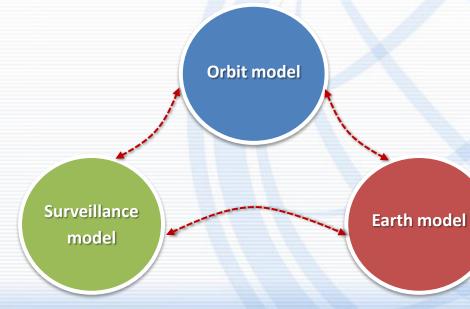
× •

\*

# **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)





零

6

-

9

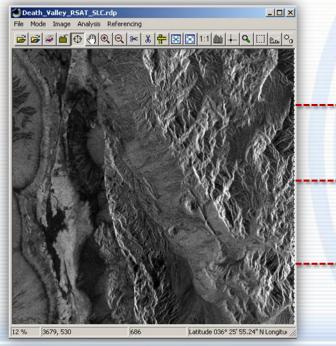
\*

 $(\mathbf{O})$ 

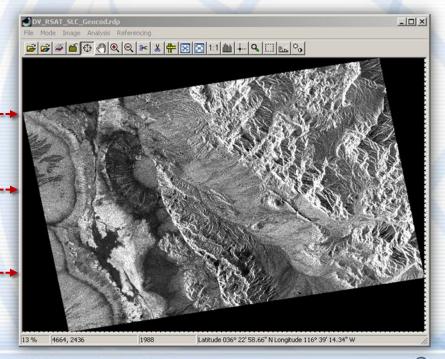
# **Geocoding processor**

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)



RACURS

粥

6

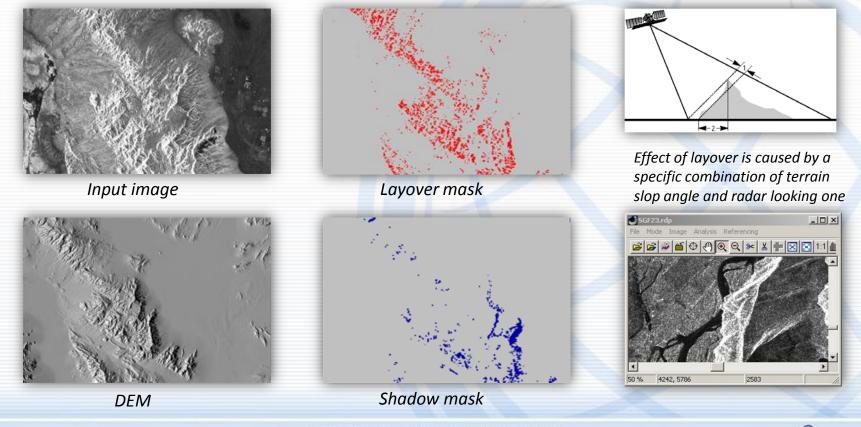
-

1

\*

# **Geocoding processor**

### Additional outputs of geocoding processor – layover and shadow masks



Software solutions in the field of photogrammetry, GIS and remote sensing +7 495 720 51 27 | info@racurs.ru | racurs.ru RACURS

粥

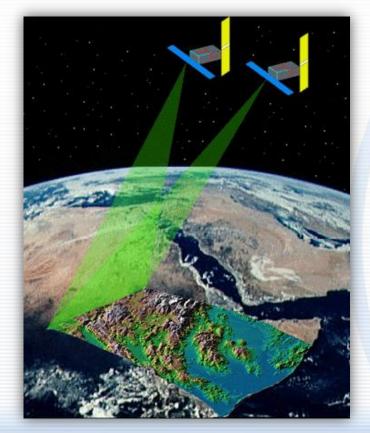
6

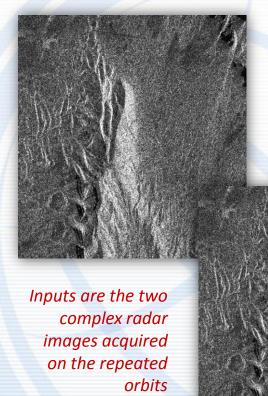
-

\*

## InSAR / DInSAR processor

#### **Radar interferometry**





Software solutions in the field of photogrammetry, GIS and remote sensing +7 495 720 51 27 | info@racurs.ru | racurs.ru

\*\* \*\*

× 40

\*

# InSAR / DInSAR processor

- Digital elevation models
  - Ground surface displacement

DInSAR Processor: project.ifp							
General Coregistration Subset	Interferogram Filtration	Unwrapping	Relief				
Master file D:\Example\ if_ref.rdp complex. signed integer, 2x16 bit, 1500x2400 1-st slave file D:\Example\ if_match.rdp complex. signed integer, 2x16 bit, 1600x2600	Preject type     Normal interferometry     Differential interferometry     Differential interferometry     Differential interferometry	3 passes )	New project Open project Save project Save project as				
2-nd slave file D:\Example\  3-rd slave file D:\Example\  DEM file D:\Example\  Example\  Example\  Example\  Example\			Run Help				

The following differential interferometry approaches are realised in processor:

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

零

6

× \*

\*

 $(\mathbf{O})$ 

Main stages of DEM generation by interferometric processor

Image coregistration (spatial matching of two images)

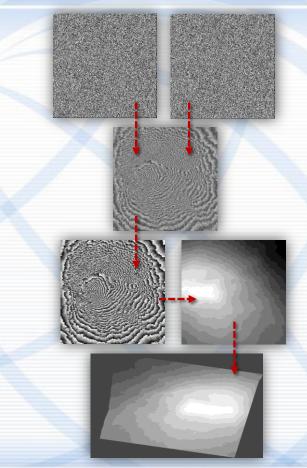
Interferogram calculation

Interferogram (phase) filtration

Phase unwrapping

Absolute phase to height recalculation

Geocoding of height matrix



粥

6

\$

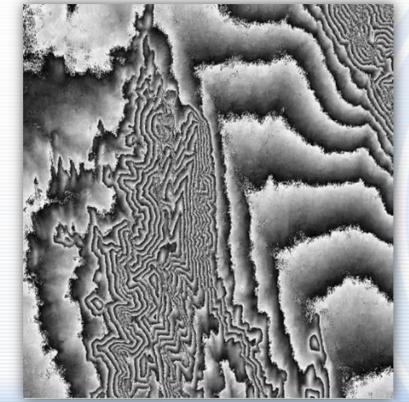
## InSAR / DInSAR processor

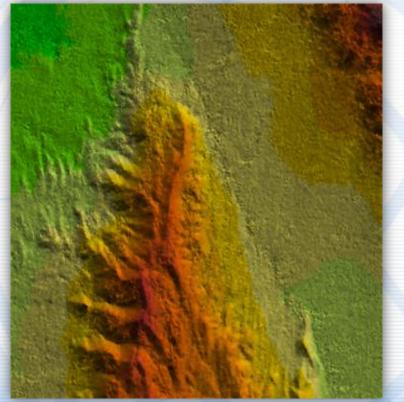
### **Radar interferometry**

Interferogram

Digital elevation model

RACURS





% \*

× •

**\$** 

 $(\mathfrak{O})$ 













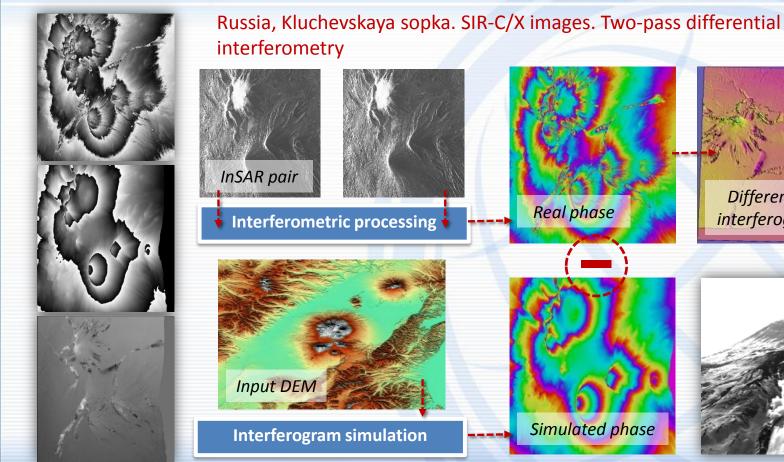


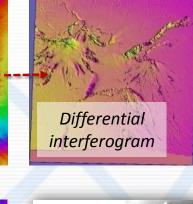






# InSAR / DInSAR processing samples









Software solutions in the field of photogrammetry, GIS and remote sensing +7 495 720 51 27 | info@racurs.ru | racurs.ru

零

6

30

-

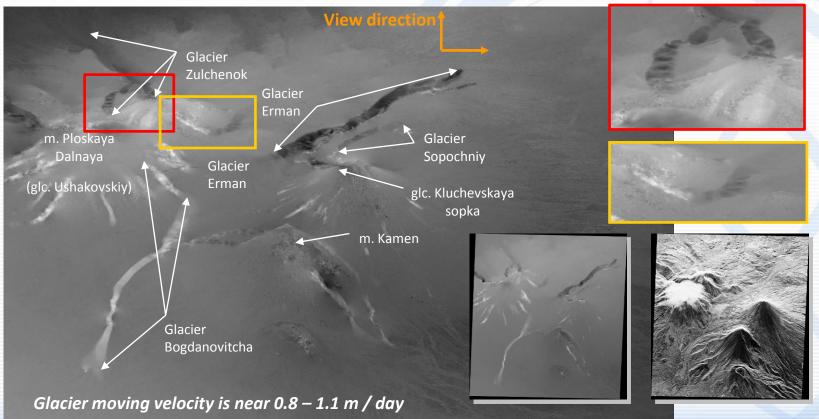
\*

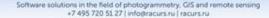




# InSAR / DInSAR processing samples

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





RACURS

零

6

3

-

\*

 $(\mathbf{O})$ 

### **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: StereoProject.spr	
Stereo processor: StereoProject.spr         ✓ General       ✓ Coregistration       ✓ Correlator       ✓ Geocoding         Input files       Input master file       D:\PHOTOMOD-Radar\PH 05. Stereo Processor\         DeathValley_S1.rdp       🚅         unsigned integer, 16 bit, 3374x3260         Input slave file         D:\PHOTOMOD-Radar\PH 05. Stereo Processor\         DeathValley_S1.rdp         unsigned integer, 16 bit, 3374x3260         Input slave file         D:\PHOTOMOD-Radar\PH 05. Stereo Processor\         DeathValley_S5.rdp         unsigned integer, 16 bit, 3374x3260	-
	Run Help Close



黎

6

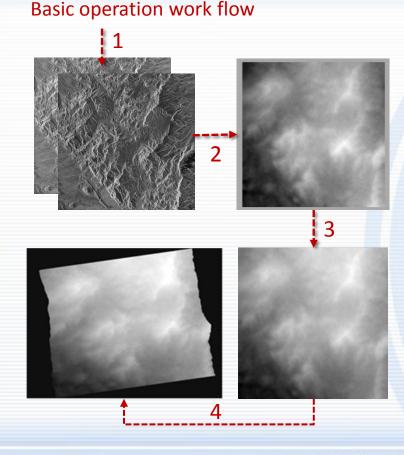
20

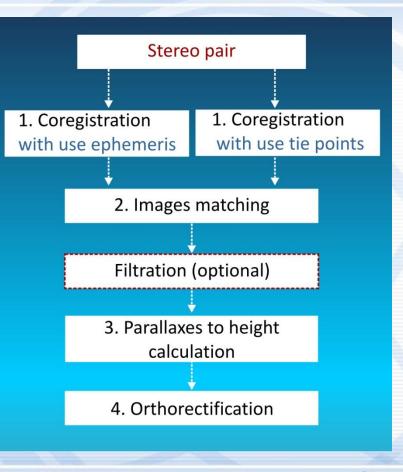
-

\*

### **Stereo processor**



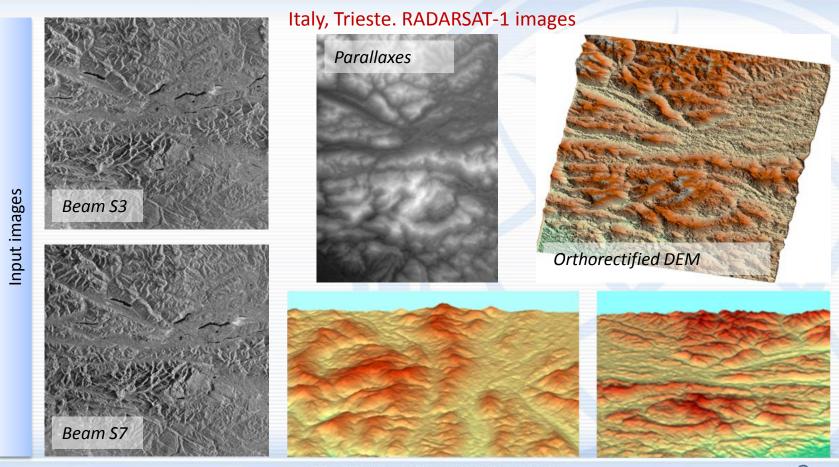




RACURS

Software solutions in the field of photogrammetry, GIS and remote sensing +7 495 720 51 27 | info@racurs.ru | racurs.ru

## **Stereo processing samples**



RACURS

幋

6

3

1

\*

 $\bigcirc$ 

### Land cover classification with SAR Polarimetry





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



粥

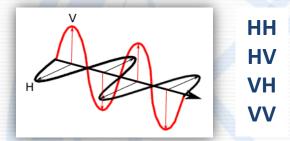
6

-

\$



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.



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.



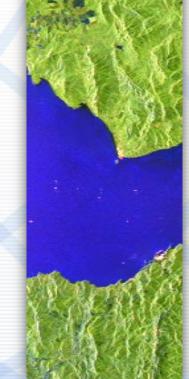
黎

1

\*

### Land cover classification with SAR Polarimetry

ISAR Processor - Beta version: gibraltar1.ppr		×	
✓ Matrix ✓ Subset ✓ Basis ✓ Descriptor	✓ Filtration ✓ Decomposition ✓ Classification		
HH channel E:\Проекты обработки\RSAT2_PolSAR_Gibraltar\ Gibraltar_HH.rdp complex. signed integer, 2x16 bit, 2156x11739 HV channel E:\Проекты обработки\RSAT2_PolSAR_Gibraltar\ Gibraltar_HV.rdp complex. signed integer, 2x16 bit, 2156x11739	Input components of scattering matrix         Complex       Real         © HH, HV, VH, VV         © HH, VH         © HH, VH         © HV, VV         © HH, VW         © HH, VW         © HH, VW         © HH, VV	New project	X
VH channel E:\Проекты обработки\RSAT2_PolSAR_Gibraltar\ Gibraltar_VH.rdp complex. signed integer, 2x16 bit, 2156x11739 W channel E:\Проекты обработки\RSAT2_PolSAR_Gibraltar\ Gibraltar_W.rdp complex. signed integer, 2x16 bit, 2156x11739			X
Scattering matrix color representation Sinclair color coding Show Pauli color coding Show		Run Help Close	



RACURS

Software solutions in the field of photogrammetry, GIS and remote sensing +7 495 720 51 27 | info@racurs.ru | racurs.ru

% **()** % ∰

⇔

١

F

### 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

Software solutions in the field of photogrammetry, GIS and remote sensing +7 495 720 51 27 | info@racurs.ru | racurs.ru

粥

9

\*











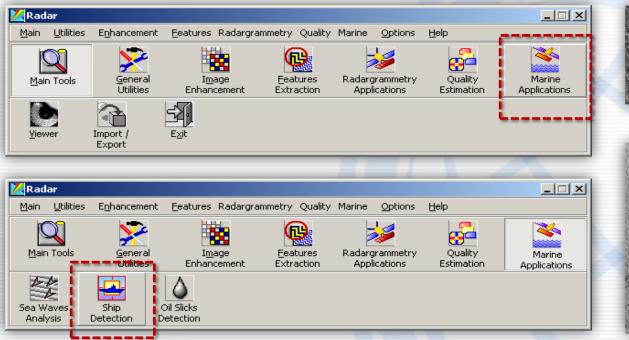






### **Ship detection processor**

#### 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.

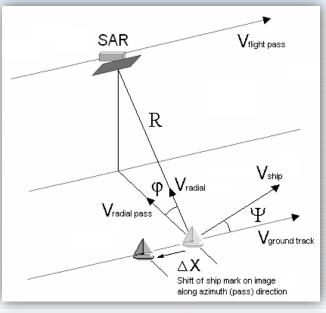


粥

1

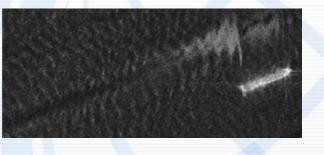
\$

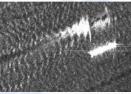
### **Ship detection processor**



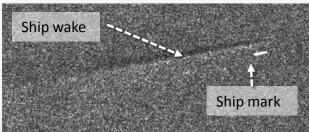
Procedure of ship detection and moving properties evaluation is based on knowledge of following parameters:

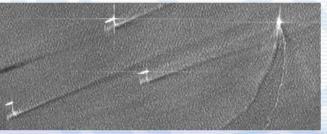
- SAR platform position
- radar signal characteristics
- survey geometry characteristics





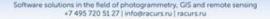








RACURS



粥

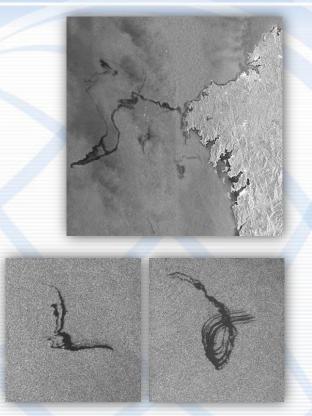
-

\*

### **Slick detection processor**

**Oil slicks detection** 

						accection
🔀 РНС	DTOMOD	-Radar				
<u>M</u> ain	<u>U</u> tilities	E <u>n</u> hancement	<u>F</u> eatures Radargra	Options Help		
Main	Main Tools		I <u>m</u> age Enhancement	Eeatures Extraction	Radargrammetry Applications	Marine Applications
<u>V</u> iew	Per	Import / Export	E <u>xit</u>			
	_					
🔀 PHOTOMOD-Radar						
<u>M</u> ain	<u>U</u> tilities	E <u>n</u> hancement	<u>F</u> eatures Radargra	mmetry Marine	Options <u>H</u> elp	
<u>M</u> ain	Tools	<u>G</u> eneral Utilities	I <u>m</u> age Enhancement	Eeatures Extraction	Radargrammetry Applications	Marine Applications
Oil Sli Detec						- appreciation is

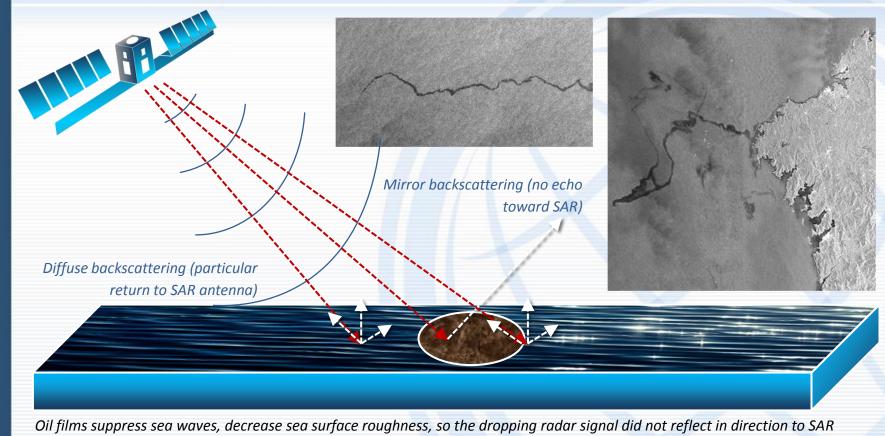


RACURS

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.

\* \* \* \* \* 0

### **Slick detection processor**



antenna.

粥

6

-

\*

## **Slick detection processor**

### Oil slick detection work flow

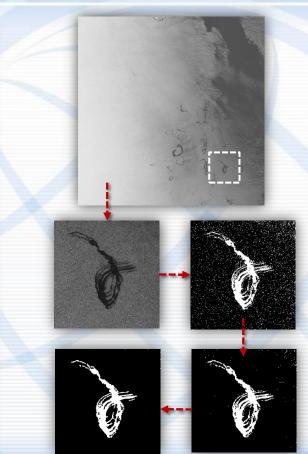
Subset of interested areas

Adaptive thresholding

Iterative classification

Iterative filtration

Slick statistics calculation



RACURS

粥

6

1

\*

### Sea waves analysis tool

					cu marcs a	and and and and and and		
🛃 PH	отомор	-Radar				_ 🗆 ×		
<u>M</u> ain	<u>U</u> tilities	E <u>n</u> hancement	<u> </u>	ammetry Marine	<u>O</u> ptions <u>H</u> elp			
Mai	n Tools	<u>G</u> eneral Utilities	I <u>m</u> age Enhancement	Eeatures Extraction	Radargrammetry Applications	Marine Applications		
<u>V</u> iev	wer	Import / Export	E <u>x</u> it					
PHOTOMOD-Radar								
Main	<u>U</u> tilities	Enhancement	Eeatures Radargra	ammetry Marine	Options <u>H</u> elp			
Mair	n Tools	<u>G</u> eneral Utilities	I <u>m</u> age Enhancement	Eeatures Extraction	Radargrammetry Applications	Marine Applications		
k	2		6					

#### 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

	ea waves a	nalysis	
D:\14. Sea Waves Analysis\ SeaWaveScene.rdp unsigned integer, 16 bit, 4593x8559	Lew project pen project ave project ve project as		2
	Run Help Close	Sea Waves Analysis: Project.wdp  Input Subset Spectrum Analysis  Parameters of map Step, pixels 10 Vindow size 128x128 Vindow size Period fin j distribution map PeriodMap.rdp Show Azimuth (grad ) distribution map AzimuthMap.rdp Show Wave height (m.) distribution map Vind velocity (m/aec.) distribution Wind velocity (m/aec.) distribution Wind velocity (m/aec.) distribution	X Map New project Open project Save project Save project as Run Help

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



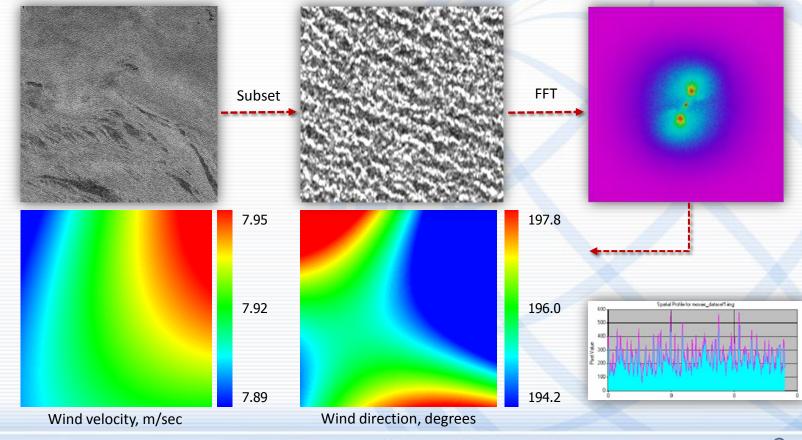
粥

-

\*

# Sea waves analysis tool

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



RACURS

黎

-

\*

### **Coherent change detection**

		eatures Radarg <b>ram</b>	makut Marina d	Options Help	_ 🗆 🗙	and the second second
Main Utilities	General Utilities	Image Enhancement	R	adargrammetry Applications	Marine Applications	
🔀 рнотомор					_ IX	
<u>Main</u> Utilities	Enhancement E	Eeatures Radargram		Options <u>H</u> elp	Marine Applications	
Change M Detection	D Classifier Pol	ISAR Texture essor Analysis				

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.

RACURS

黎

5

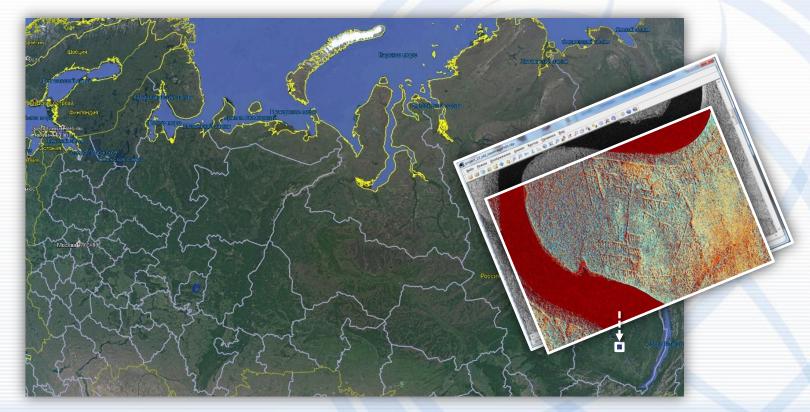
**1** 

翁

(3)

## **Radar projects**

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





幋

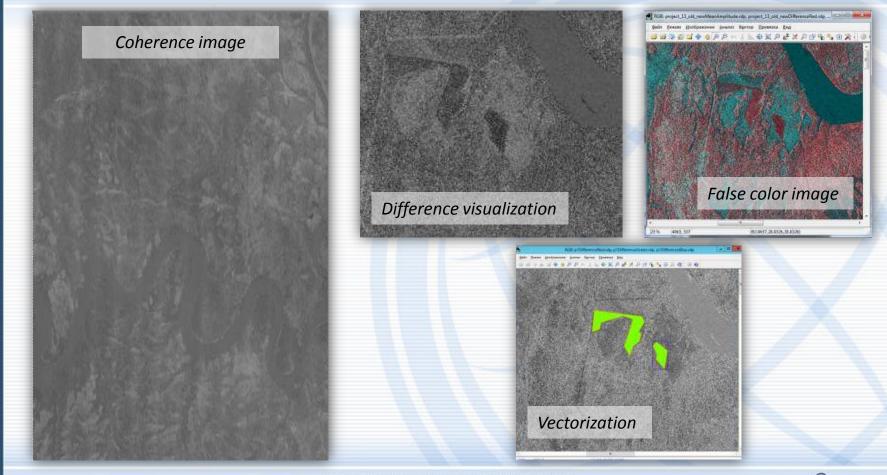
6

-

1

\*

### Radar projects. Detecting changed areas and coherent combining



Software solutions in the field of photogrammetry, GIS and remote sensing +7 495 720 51 27 | info@racurs.ru | racurs.ru

RACURS

幋

1

\*

# Thank you for attention!



\* \* \* \*

\*