sarmap

SARscape®

About Synthetic Aperture Radar

SAR systems mainly acquire data in different ways, such as i) single or dual channel mode (for instance HH or HH/HV or VV/VH), ii) interferometric (single- or repeat-pass) mode, iii) polarimetric mode (HH,HV,VH,VV), and finally, iv) by combining interferometric and polarimetric acquisition modes. Obviously, different acquisition modes are subject to different processing techniques. They are:

- **Processing of SAR Intensity**
  The product generation is limited to the **intensity** processing.
- **Interferometric SAR (InSAR/DInSAR) Processing**
  The product generation includes **intensity**, and **interferometric phase** processing.
- **Polarimetric SAR (PolSAR) Processing**
  The product generation includes **intensity**, and **polarimetric phase** processing.
- **Polarimetric-Interferometric SAR (PolInSAR) Processing**
  The product generation includes **intensity**, **polarimetric**, and **interferometric phase** processing.

Supported spaceborne SAR systems

ERS-1/2	ESA	C-band
JERS-1 SAR	JAXA	L-band
RADARSAT-1/2	CSA & MDA	C-band
ENVISAT ASAR	ESA	C-band
ALOS PALSAR-1	JAXA	L-band
TerraSAR-X	Germany	X-band
SAR Lupe	Germany	X-band
COSMO-SkyMed	ASI	X-band
RISAT-1	ISA	C-band
Sentinel-1	ESA	C-band
ALOS-2	JAXA	L-band

Supported airborne SAR systems

OrbiSAR-1	up to 0.5 m	X, P-band	1-4 pol
TELAER	up to 0.5 m	X-band	1 pol
E-SAR	up to 1 m	P,L,C,X-band	1-4 pol
RAMSES	up to 0.25 m	P,L,S,C,X,Ku,Ka,W-band	1-4 pol

UAV SAR in Stanag format

SARscape® - Modules

- **Basic**
  It includes a set of processing steps for the generation of SAR products based on intensity. This module is complemented by a multi-purpose tool and by:

  - **Focusing**
    It supports the focusing of ERS-1/2 SAR, JERS-1 SAR, ENVISAT ASAR (including Wide Swath developed by Aresys) and ALOS PALSAR-1 data.

  - **Gamma & Gaussian Filter**
    It includes a whole family of SAR specific filters. They are particularly efficient to reduce speckle, while preserving the radar reflectivity, the textural properties and the spatial resolution, especially in strongly textured SAR images. Developed in collaboration with Privateers.

SARscape® - Modules

- **Interferometry**

  It supports the processing of Interferometric SAR (2-pass interferometry, InSAR) and Differential Interferometric SAR (n-pass interfereometry, DInSAR) data for the generation of Digital Elevation Model, Coherence, and Land Displacement/ Deformation maps.

  This module is complemented by:

  - **ScanSAR Interferometry**

    It offers the capabilities to process InSAR and DInSAR data over large areas (400 by 400 km). Developed in collaboration with Aresys.

  - **Interferometric Stacking**

    Based on **Small Baseline Subset** (SBAS) and **Persistent Scatterers** (PS) techniques this module enables to determine displacements of individual features.

  - **SAR Polarimetry / Polarimetric Interferometry**

    It supports the processing of polarimetric and polarimetric interferometric SAR data.

SARscape® - Modules

- **Quality Assessment Tool**

  In order to quantitatively assess the geometric, radiometric, and polarimetric quality of SAR products, a Quality Assessment Tool (QAT) based on a solid methodology is proposed. The overall architecture of the QAT system supports the quality assessment for ENVISAT ASAR (IM,AP,WS) and RADARSAT-1 and -2 (FB,SB,WB,EB,ScanSAR) data.

SARscape® - Modules

Basic, Interferometry, Interferometric Stacking, and Quality Assessment Tool modules are stand alone. The other modules require either Basic or Interferometry as shown below.

	Basic	Interferometry
Focusing *		
Gamma & Gaussian Filtering		
ScanSAR Interferometry		
PolSAR/PolInSAR		

* Focusing requires Basic or, alternatively, the Interferometry module

Basic Module

The Basic module includes a set of processing steps for the generation of spaceborne and airborne SAR products based on intensity and coherence. This is complemented by a multi-purpose tool, which includes a wide range of functions - from image visualisation, to Digital Elevation Model import and interpolation, to cartographic and geodetic transforms.

Following processing capabilities are supported:

- Multilooking
  Generation of multi-looking image from Single Look Complex data.

- Co-registration
  In cases where multiple image data sets cover the same region, it is necessary that pixels in different images correspond so that pixel-by-pixel comparisons can be carried out. Spatial registration may be necessary, and also resampling, in cases where pixel sizes vary. Coregistration is carried out automatically.

Basic Module

- Filtering

  It supports a number of conventional single-image filters based on the classical minimum mean square error and on the anisotropic non-linear diffusion theory. These set of filters is complemented by two advanced multi-temporal multi-sensor despeckling filters.

- Feature Extraction

  Different feature parameters, which are generally used as inputs for classification or quantitative analysis, can be extracted from intensity and coherence. These are based on first order and time-series statistics.

- Geocoding, Radiometric Calibration and Normalisation

  Ellipsoidal or terrain geocoding, using nominal parameters or Ground Control Points, enables the transformation from radar co-ordinates (either ground or slant range) into a given cartographic reference system using a rigorous range-Doppler approach. The radiometric calibration, which is performed during the geocoding, is based on the exploitation of the radar equation. In addition, the radiometric normalisation enables to empirically correct the effects of the incidence angle on sigma nought by applying a modified cosine correction.

Basic Module

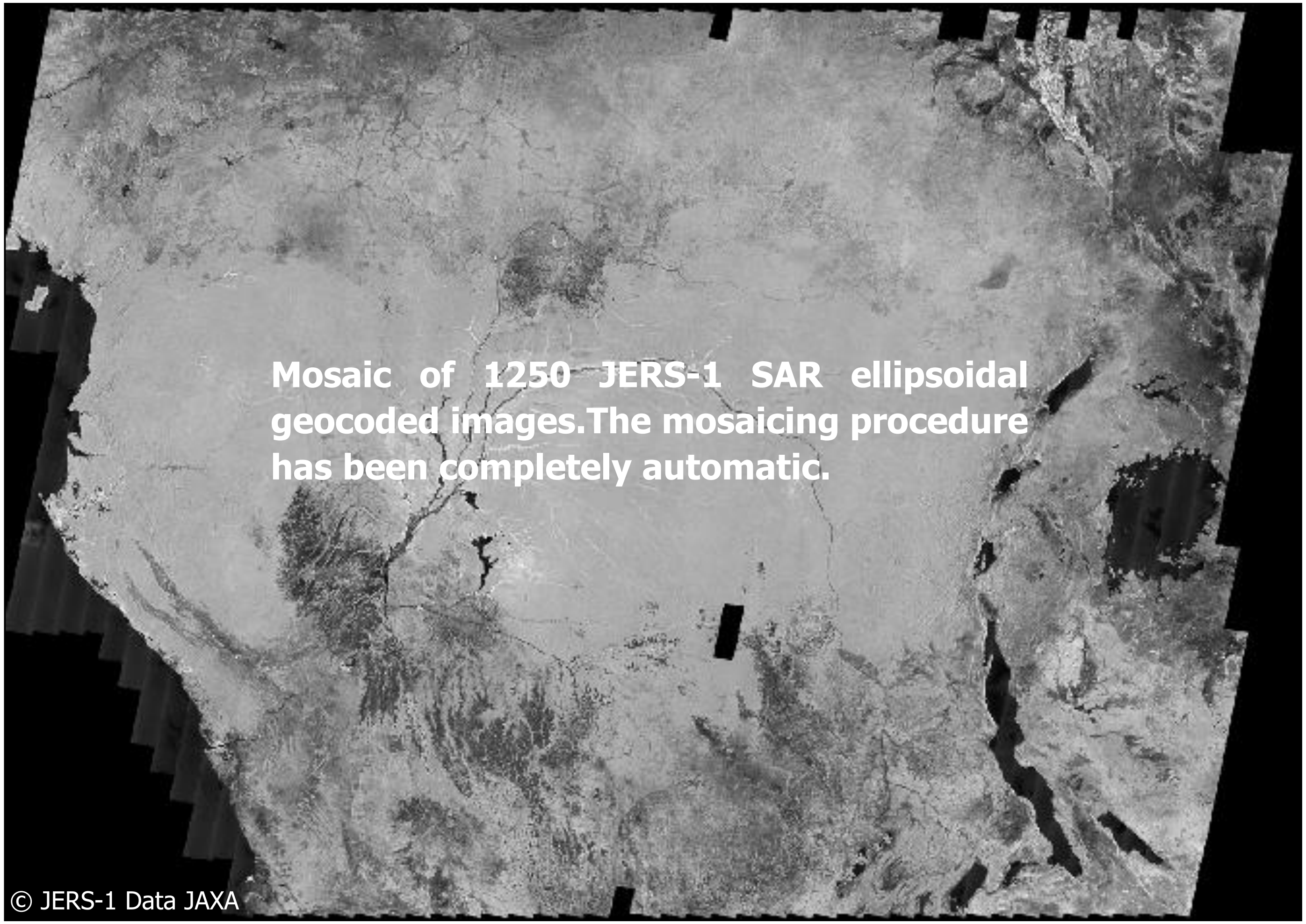
- Mosaicing

  It often occurs that the area of interest is covered by several images. In this case SAR images (amplitude and/or coherence) or products (classification results) can be combined in order to obtain an entire coverage of the area. When mapping large areas using SAR data, individual image frames have to be seamlessly joined together to create a consistent mosaic across the region. This method refines the radiometric variations by comparing the images to be mosaiced in the overlapping areas.

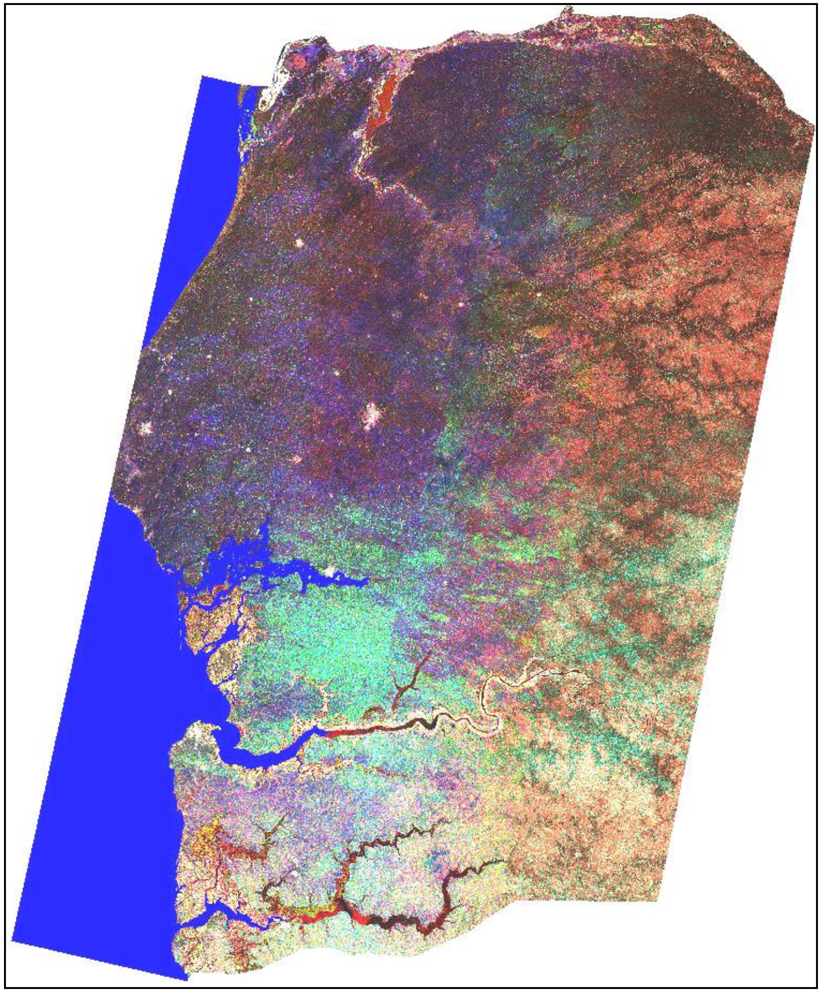
Basic Module

- **Tools**
  - Reading and automatic mosaicing of SRTM, RAMP, GTOPO30, ACE DEM data
  - Multi-source Digital Elevation Model combination
  - Shape, image and DEM cartographic and geodetic transformation
  - Slope image generation
  - Point target analysis (SAR data)
  - Image statistics calculation
  - Multi-image operations
  - Image resampling
  - Images and DEMs interpolation
  - Sample selection
  - Raster to shape data conversion
  - Raster data slicing
  - Complex interferogram to phase and module conversion and backward-transformation
  - Cartographic to slant geometry conversion
  - File transformations

Basic – Fully automated JERS-1 SAR Mosaic



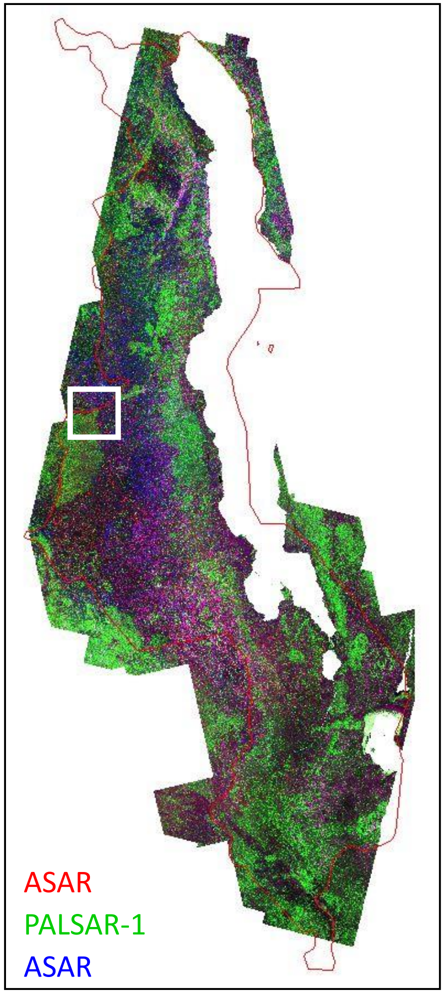
Basic – Multi-temporal Mosaic, ENVISAT ASAR Data

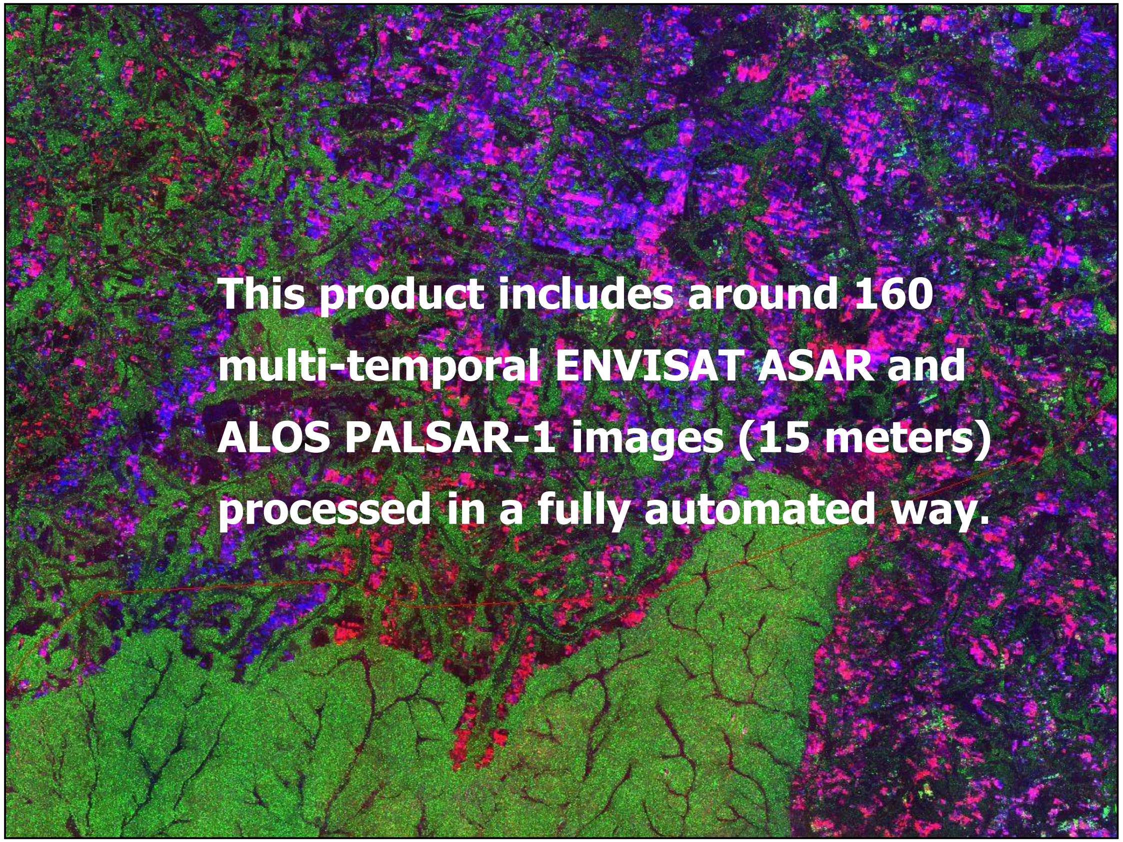


This product includes around 180 **multi-temporal** ENVISAT ASAR images (3 dates, acquired between May and August 2007) processed in a fully automated way.

Senegal

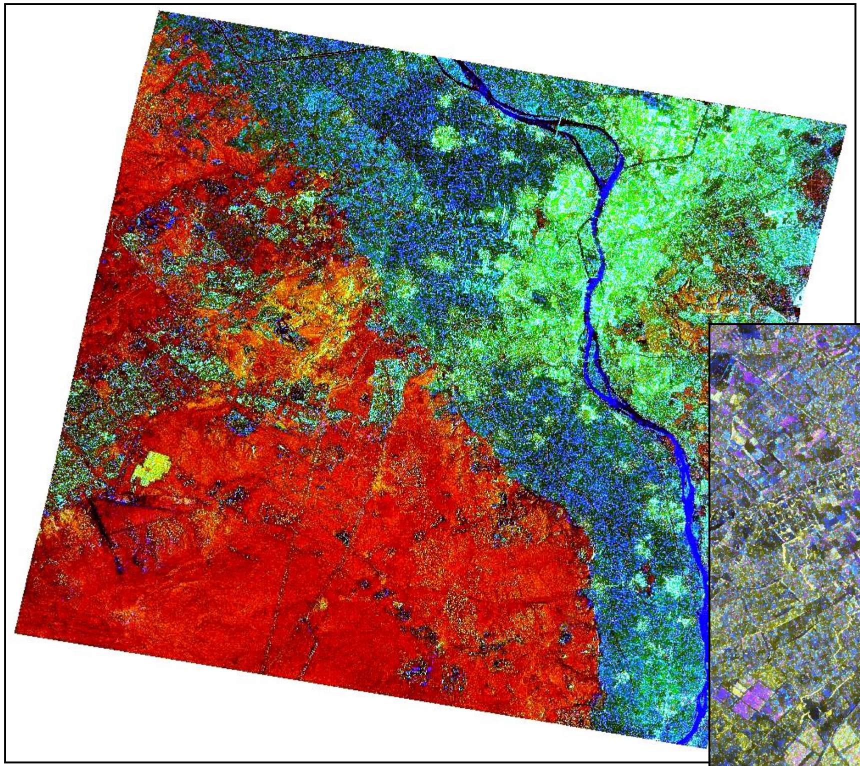
Basic – Multi-temporal Multi-sensor Mosaic, ASAR and PALSAR data





Malawi

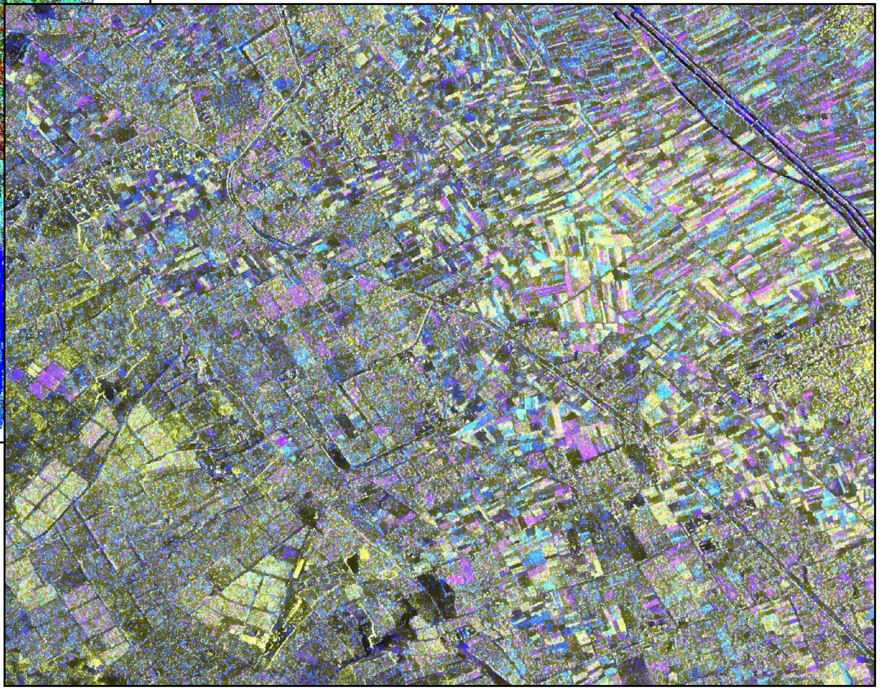
Basic – Precise Terrain Geocoding of COSMO-SkyMed-1/2 Products



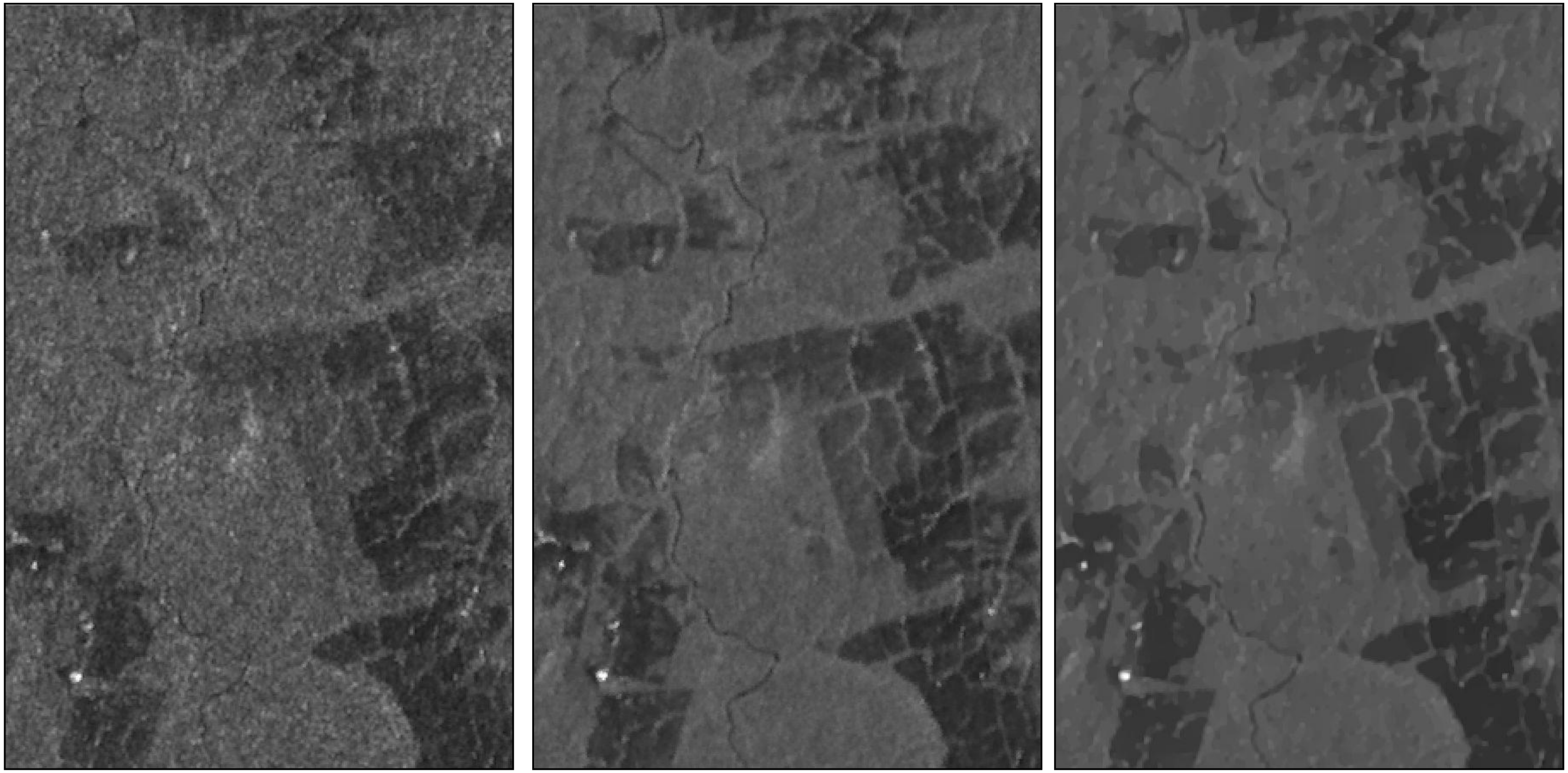
Coherence
Mean Intensity
Intensity Difference

Time interval 8 days

Intensity date 1
Intensity date 2
Intensity Difference



Basic – Multi-temporal Speckle Filtering

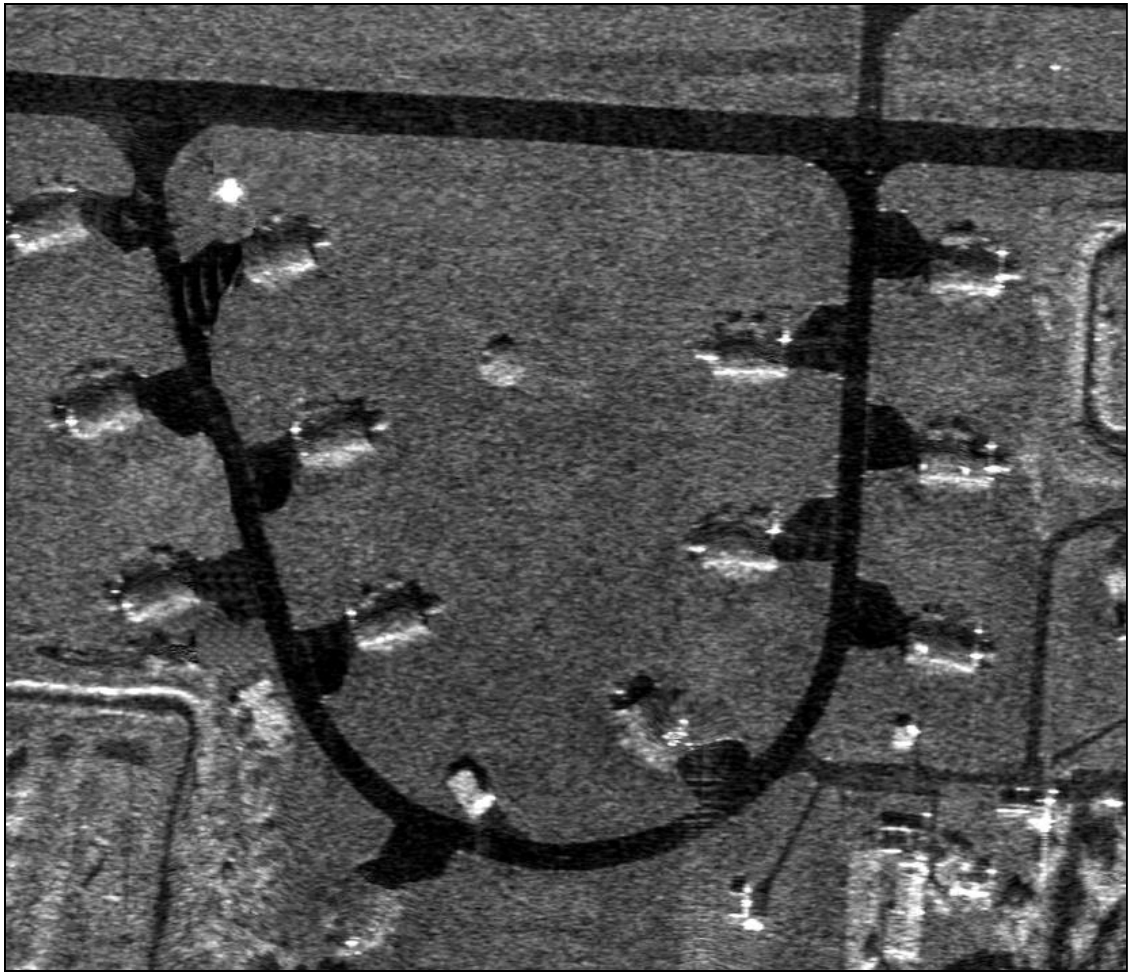


Original

Multi-temporal De Grandi

Multi-temporal Anisotropic non-linear Diffusion

Basic – Terrain Geocoded Airborne SAR Data - Quality and Level of Detail



Focusing Module

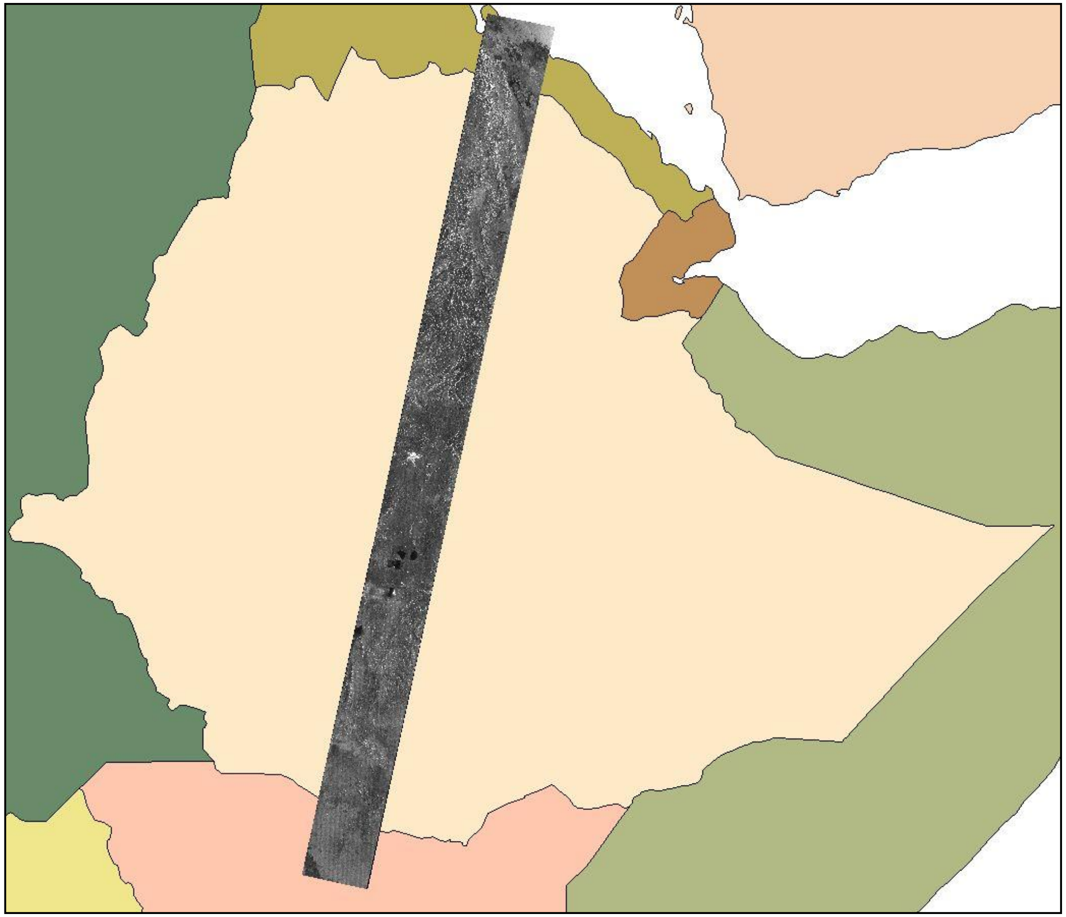
This module provides Single Look Complex (SLC) **frame** and **strip** based products starting from the following raw data:

- ERS-1/2 SAR
- JERS-1 SAR
- ENVISAT ASAR Image Mode
- ENVISAT ASAR Alternating Polarization
- ENVISAT ASAR Wide Swath (based on an algorithm developed by POLIBA)
- ALOS PALSAR-1 Single Polarization
- ALOS PALSAR-1 Dual Polarization
- ALOS PALSAR-1 Full Polarization

Note that:

- The mosaicing of ERS-1/2 SAR and ENVISAT ASAR raw data is supported;
- SLC data generated with this module are not appropriate to derive absolutely radiometric calibrated values.

Focusing Module – Strip Data Processing



ENVISAT ASAR
Image Mode

Ethiopia

Gamma & Gaussian Filtering Module

This module, which is dedicated to the speckle removal in SAR images, includes a whole family of SAR specific filters. The algorithms are based on Gamma and Gaussian-distributed scene models. They are particularly efficient to reduce speckle noise, while preserving the radar reflectivity, the textural properties and the spatial resolution, especially in strongly textured SAR images.

In presence of scene texture, to preserve the useful spatial resolution, e.g. to restore the spatial fluctuations of the radar reflectivity (texture), an A Priori first order statistical model is needed. With regard to SAR clutter, it is now well accepted that the Gamma-distributed scene model is the most appropriate. The Gamma-distributed scene model, modulated by, either an independent complex-Gaussian speckle model (for SAR SLC images), or by a Gamma speckle model (for multilook detected SAR images), gives rise to a K-distributed clutter. Nevertheless, the Gaussian-distributed scene model remains still popular, mainly for mathematical tractability of the inverse problem in case of multi-channel SAR images (multivariate A Priori scene distributions).

Gamma & Gaussian Filtering Module

Supported SAR filtering methods:

- Single Channel Detected SAR data

  - Gamma-Gamma Maximum A Posteriori (MAP)
  - Gamma-Distribution-Entropy MAP (DE MAP)
  - Gamma A Posteriori Mean

- Multi Channel Detected SAR data

  - Gamma-Gaussian MAP filter for uncorrelated speckle
  - Gaussian-Gaussian MAP filter for correlated speckle
  - Gaussian-DE MAP filter for correlated speckle

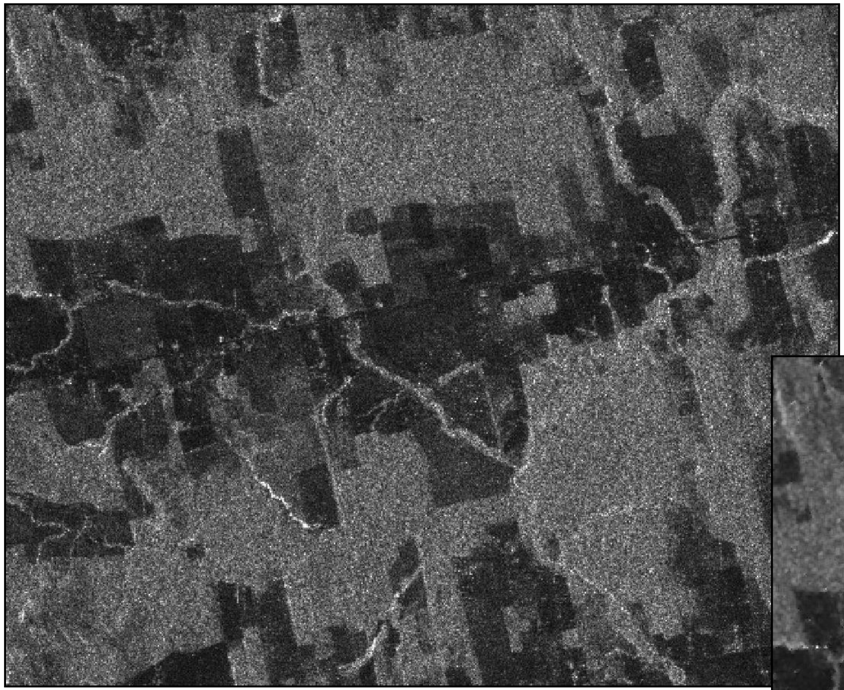
- Complex SAR data

  - Single Look Complex: Complex Gaussian-DE MAP
  - Separate complex looks or interferometric series: Complex Gaussian-Gamma MAP

- Polarimetric SAR data

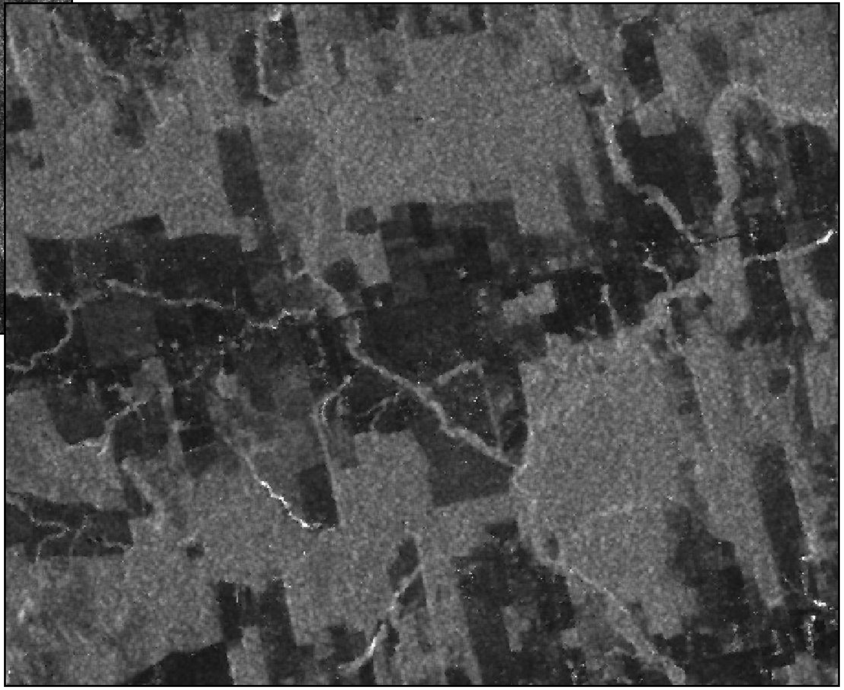
  - Complex Wishart-Gamma MAP
  - Complex Wishart-DE MAP

Gamma & Gaussian Filtering – ALOS PALSAR-1 FBS



Original

Gamma-Gamma MAP



Gamma & Gaussian Filtering – RADARSAT-2 Polarimetric

Original

Complex Wishart-Gamma MAP

Interferometry Module

This module supports the processing of Interferometric SAR (2-pass interferometry, InSAR) and Differential Interferometric SAR (n-pass interferometry, DInSAR) data for the generation of Digital Elevation Model, Coherence, and Land Displacement maps.

The processing includes the following steps:

- Co-registration using Digital Elevation Model provide the proper parameters in order to align the same points in the two images.
- Common Doppler bandwidth filtering - If there is a difference in the Doppler Centroids, this step allows minimisation of the decorrelation.
- Interferogram generation - Spectral shift filtering is performed on the image pair, and the Hermitian product is calculated.
- DEM flattening - Synthetic fringes are generated from a coarser resolution DEM or ellipsoidal height, using a backward geocoding approach, and then cross-multiplied by the SAR interferogram. This step allows removal of most of the low frequency components of the wrapped phase, to ease the following phase unwrapping.

sarmap

Interferometry Module

- Adaptive filtering - The flattened complex interferogram is filtered to improve the phase SNR, improving the height accuracy of the final DEM.

- Phase unwrapping - The filtered interferogram is unwrapped by using a region growing approach.

- Phase editing – Unwrapping errors can be corrected in a semi-automatic or completely manual way.

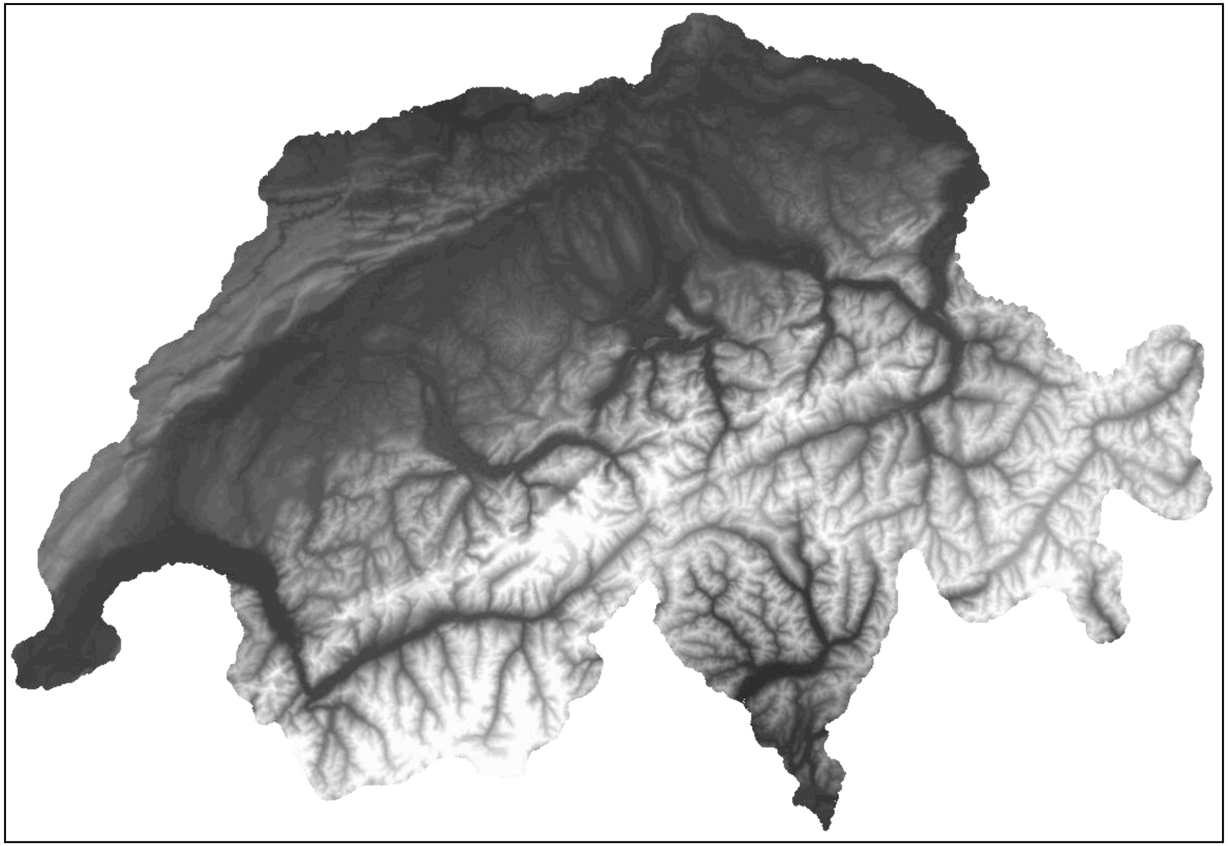
- Geometry optimisation, based on Ground Control Points - The orbits are refined in order to obtain an accurate conversion of the phase information to height and a proper geo-location. Both manual and automatic procedures for the identification of the most suitable image pixels to be used as GCPs are implemented.

Interferometry Module

- Phase to map conversion – A rigorous approach is implemented, that takes into account the range-Doppler nature of the SAR acquisition. The final product is obtained in the desired cartographic reference system, by taking into account all the necessary geodetic and cartographic parameters and transformations.

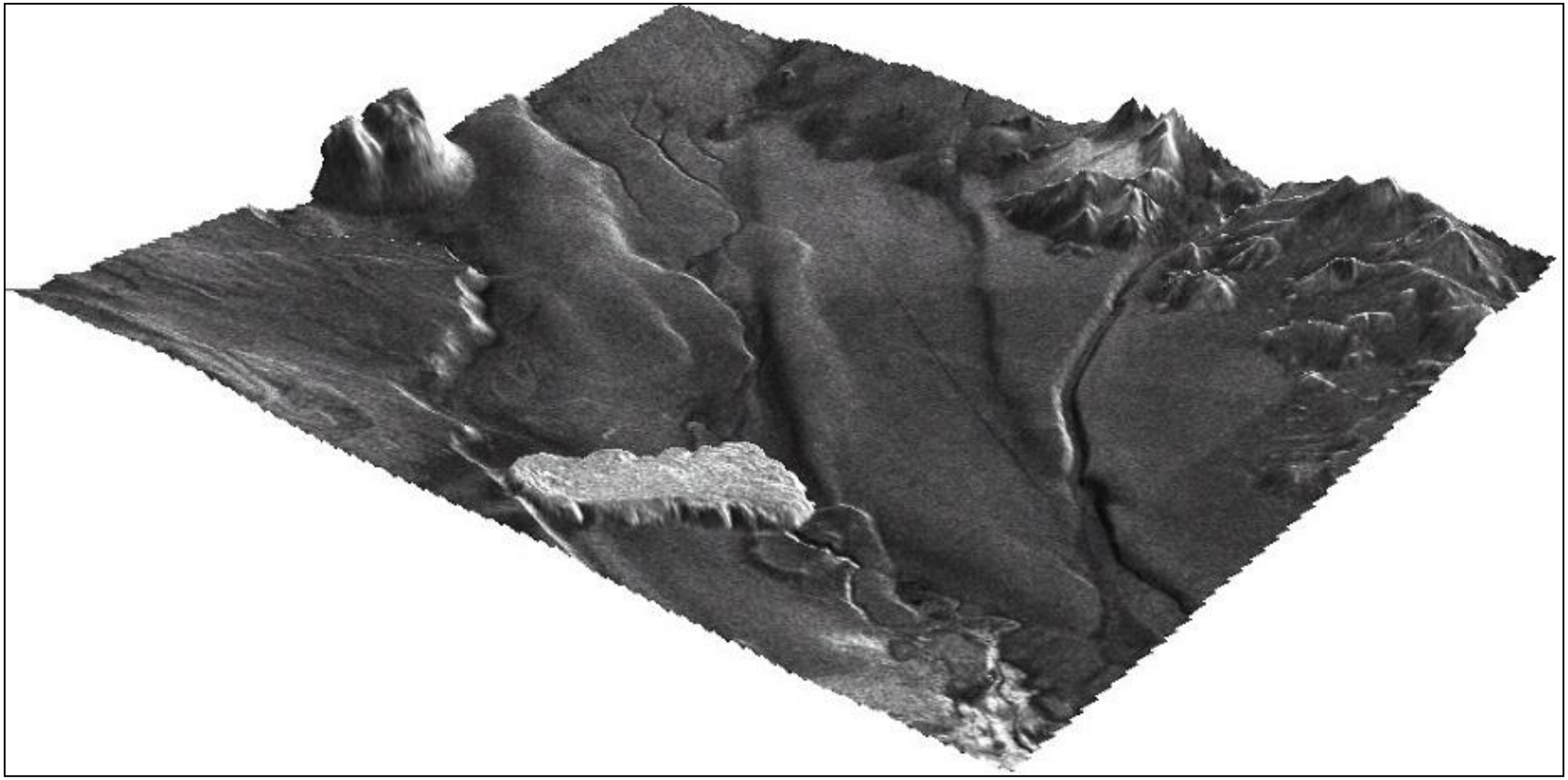
- Phase to displacement – The phase values are converted to displacement and geocoded onto a map projection. The user can enter a specific direction (*azimuth angle*) and *inclination angle* along which he assumes that the main deformation occurred, or even enter an a-priori known *deformation field* as input. For the generation of displacement maps it is mandatory to run a second iteration of the processing, from the interferogram flattening to the phase unwrapping, after the execution of the baseline fit step (which is aimed at correcting orbital inaccuracies).

Interferometry – Digital Elevation Model, ERS-Tandem



Switzerland

Interferometry – Digital Elevation Model, TerraSAR-X-1



Bolivia

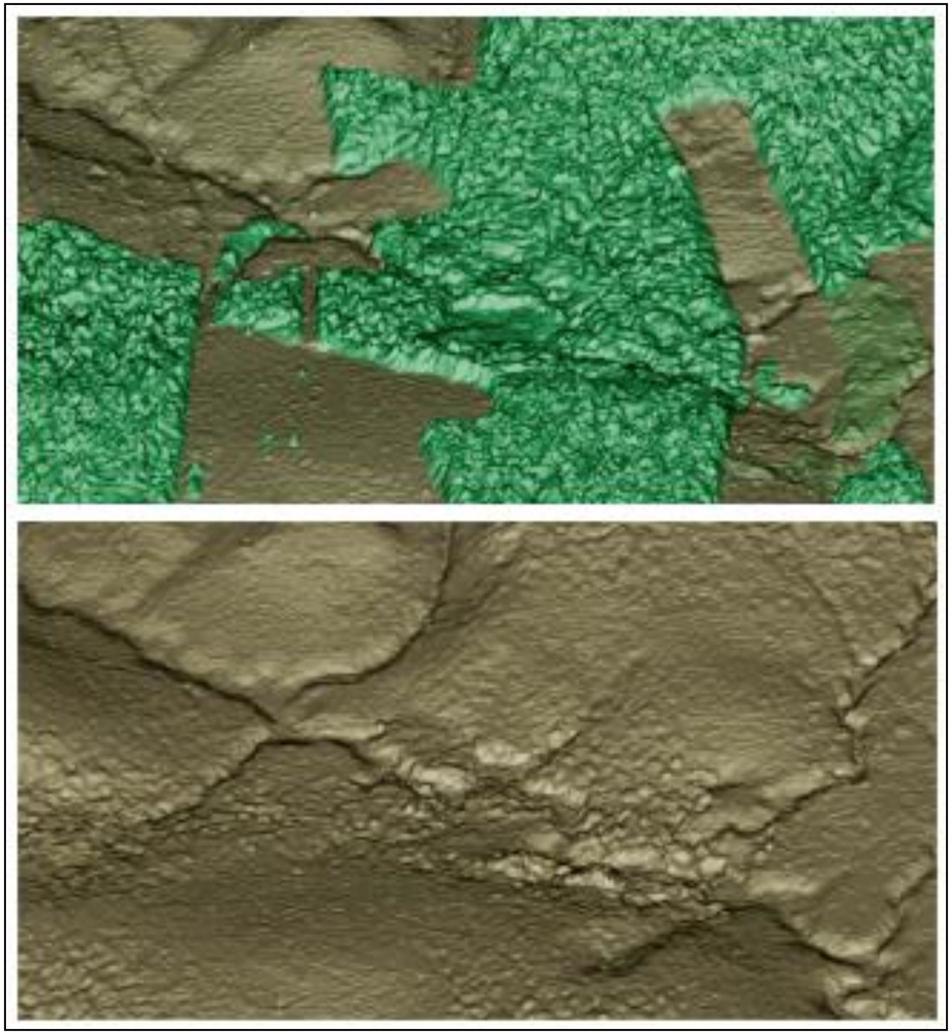
Interferometry – Digital Surface and Terrain Mode, OrbiSAR-1 data

Digital Surface Model

X-band

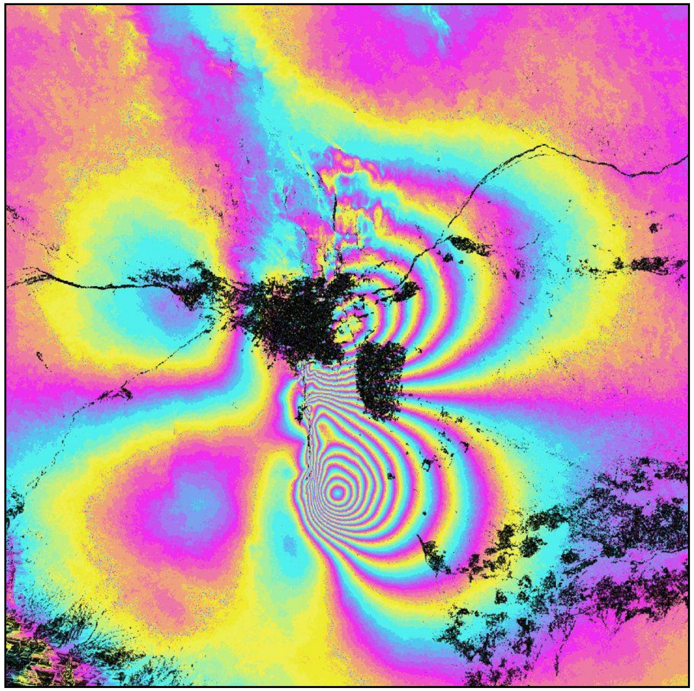
Digital Terrain Model

P-band

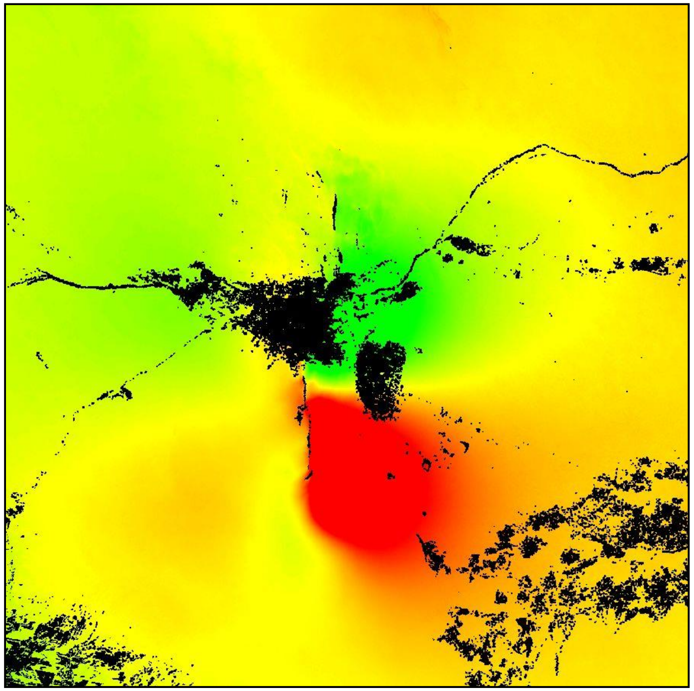


Brazil

Differential Interferometry, ENVISAT ASAR Image



Differential interferogram generated from an ASAR pair acquired on 3 December 2003 (pre-earthquake) and 11 February 2004 (post-earthquake).

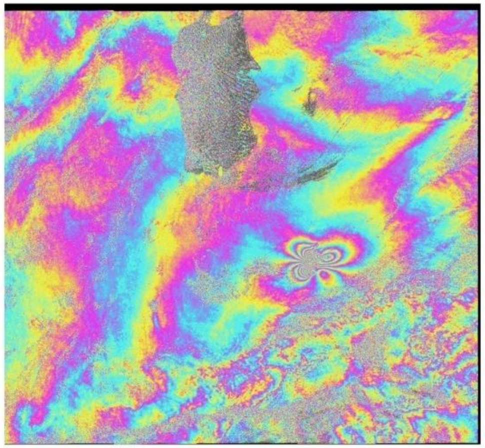


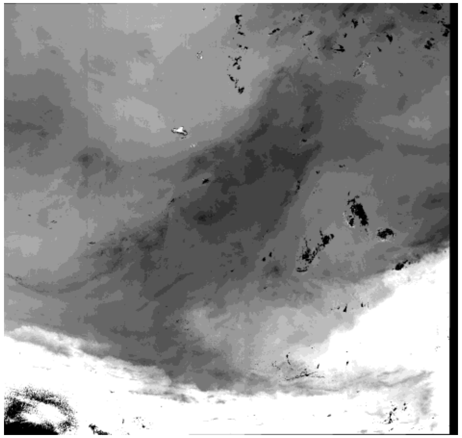
Deformation map obtained considering a strike slip fault (horizontal movement) with a N-S oriented fault plane. Red and green tones represent the areas of largest deformation, while yellowish areas correspond to smaller deformation zones.

Bam, Iran

Differential Interferometry and Atmospheric Effects

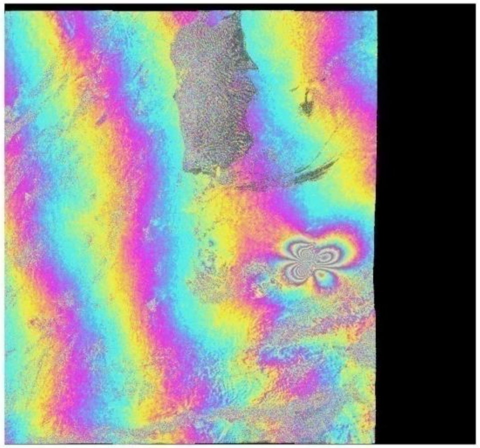
ASAR WS interferometric phase **including atmospheric artifacts**

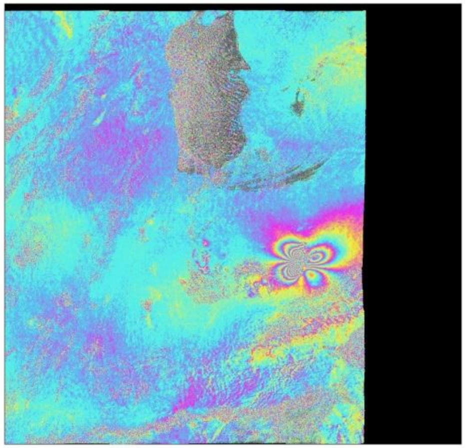




MERIS **water vapour** for master image

ASAR WS interferometric phase **after reduction of atmospheric artifacts**

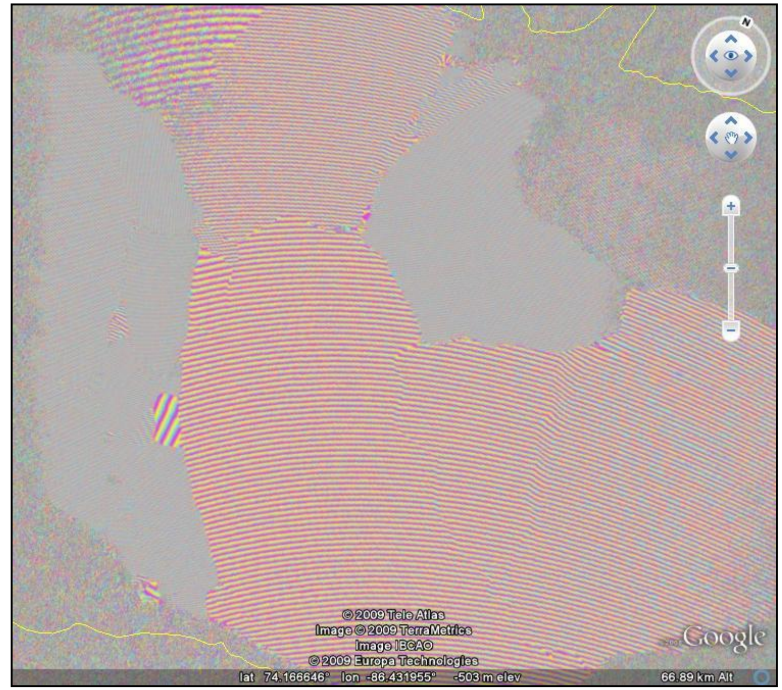




ASAR WS interferometric phase **after reduction of atmospheric artifacts** and **orbital refinement**

Differential Interferometry - Fast Moving Glaciers

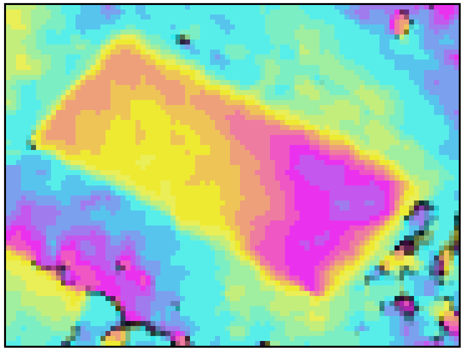
ASAR intensity of sea ice



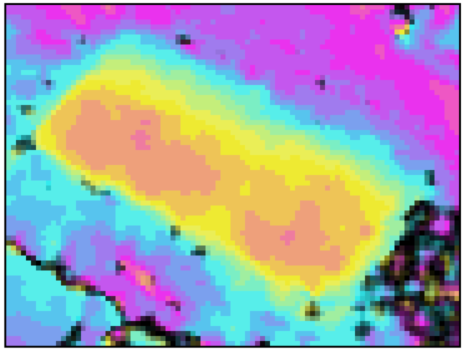
ERS-2 - ASAR 28’ phase

Greenland

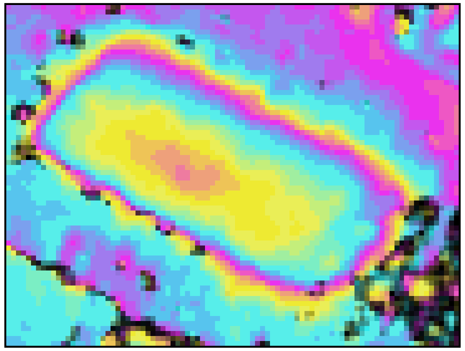
Differential Interferometry, TerraSAR-X-1



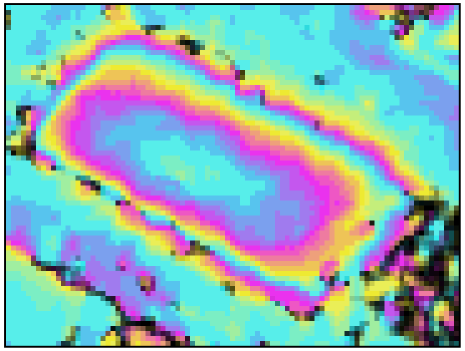
11 days



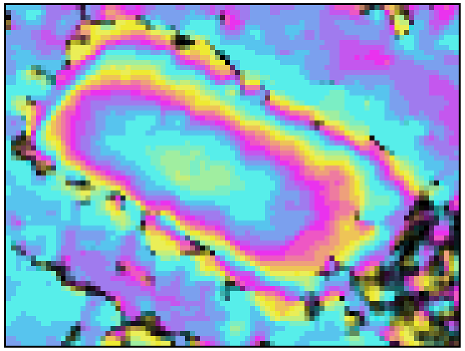
22 days



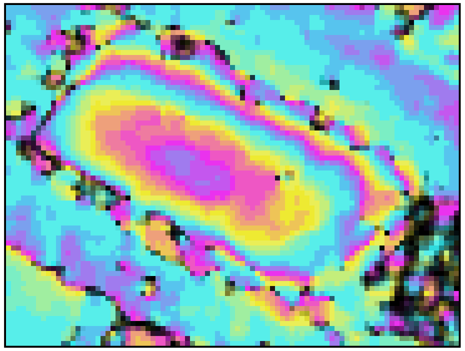
33 days



44 days



55 days

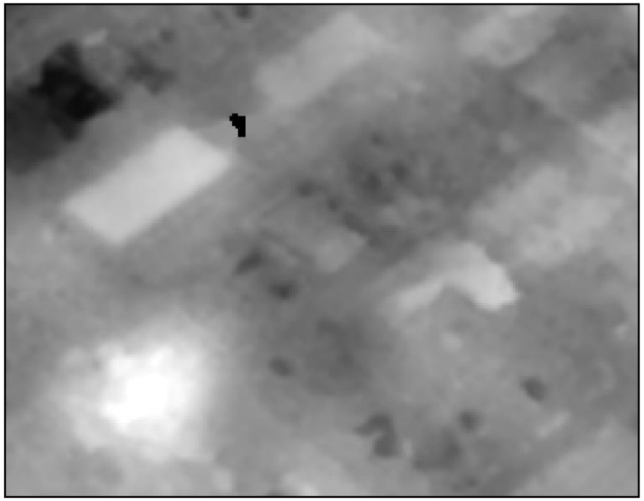


66 days

1 colour cycle ~= 1.55 cm of displacement
1 pixel = 3 meter

Barcelona

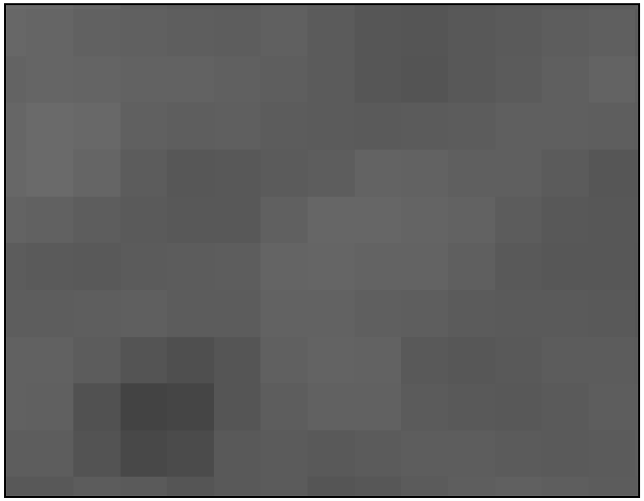
Differential Interferometry, Dual Pair Interferometry – Urban



Top Left - Non-linear Displacement Map
(dark grey -2.3 cm; bright grey +2.2 cm)

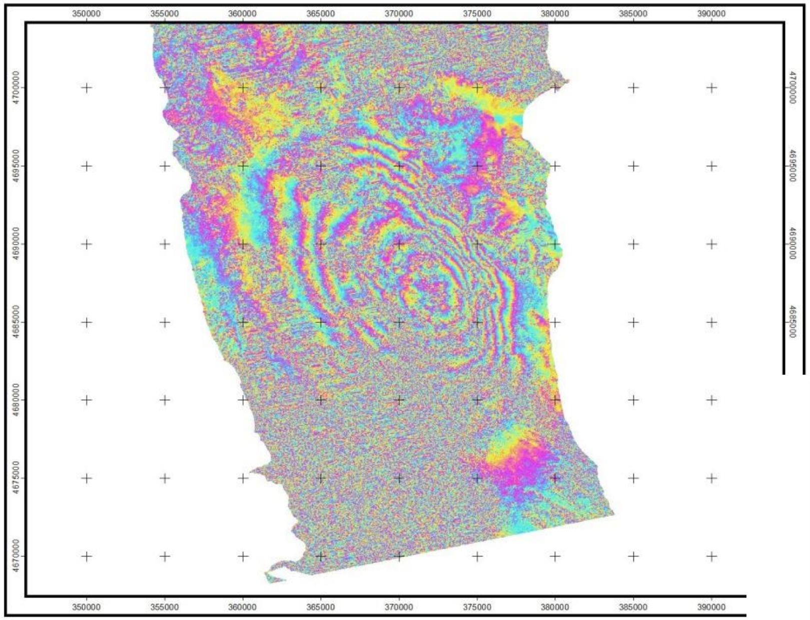
Top Right - Residual Height Map
(dark grey -15 m; bright grey +18 m)

Bottom Right - Reference DEM, SRTM-4



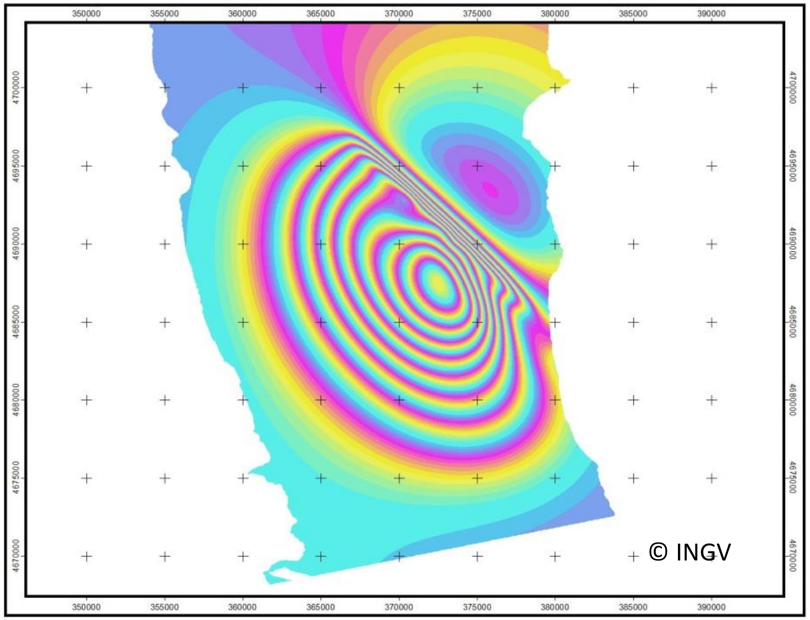
Barcelona

Differential Interferometry – Interferogram vs. Modeling



COSMO-SkyMed StripMap
differential phase

Synthetic interferogram based on
Okada (direct) model



sarmap

ScanSAR Interferometry Module

This module extends the Interferometry one to the ScanSAR mode, offering the capabilities to generate interferograms over large areas (400 x 400 km). This module enables also the generation of Digital Elevation Model, Coherence and Land Displacement maps based on ENVISAT ASAR Wide Swath data. In addition this module provides also hybrid interferometric products, by combining StripMode (ASAR Image Mode) data with ScanSAR (ASAR Wide Swath) ones.

The main processing capabilities are:

- ScanSAR Single Look Complex (SLC) Pair Overlap Estimation

  ScanSAR data alignment, and burst overlapping, is estimated using sensor orbit descriptions.

- Doppler Common Band Filtering

  Common azimuth bandwidth is selected on the master and slave bursts, minimising the signal decorrelation.

- Burst Coregistration

  Coregistration coefficients are computed using sensor orbit descriptions. The slave burst is then resampled over the master burst grid.

ScanSAR Interferometry Module

- Interferogram Generation

  Coregistered bursts are filtered along the range direction in order to minimise the geometrical decorrelation; either Synthetic fringes or a flat Earth interferogram can be used for this purpose. The interferogram is subsequently generated as an Hermitian product between masterand coregistered slave bursts.

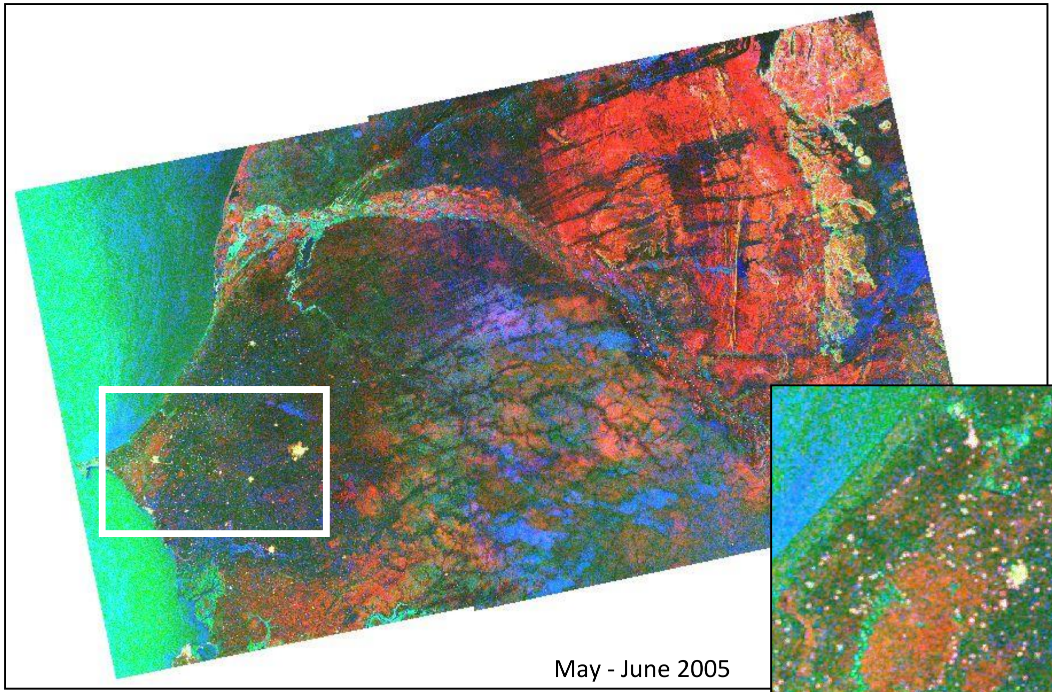
- Single Swath Interferogram and Single Swath Detected Image Generation

  Single burst interferograms are collected and coherently summed providing a multilooked interferogram image for each ScanSAR swath. In the same step the single bursts absolute value data are collected, weighted with a de-scalloping window, and incoherently summed, providing two (master and slave) single swath, coregistered detected images.

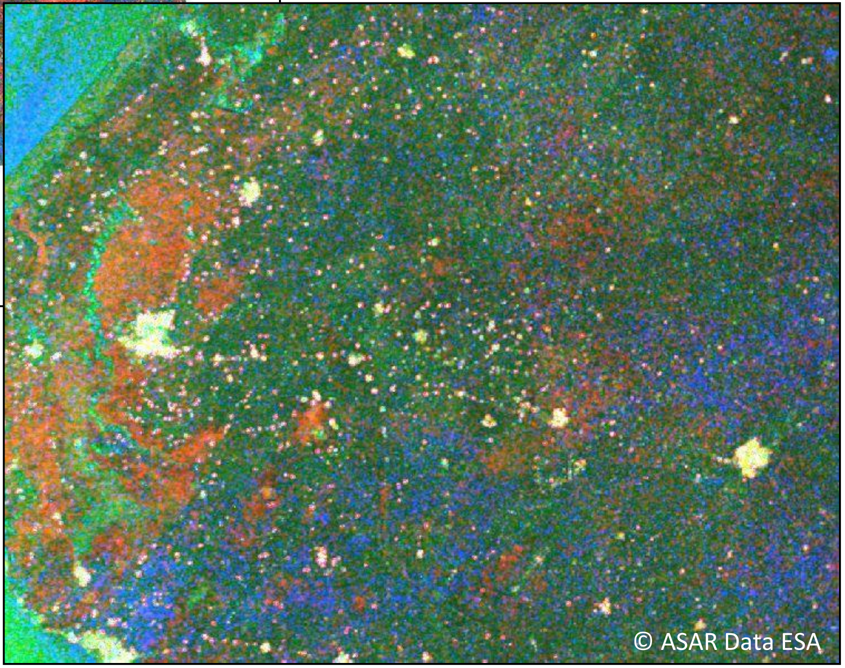
- Swaths Recomposing

  Single swath data (interferogram and detected data) are composed into multi swath images.

ScanSAR Interferometry – ENVISAT ASAR Wide Swath

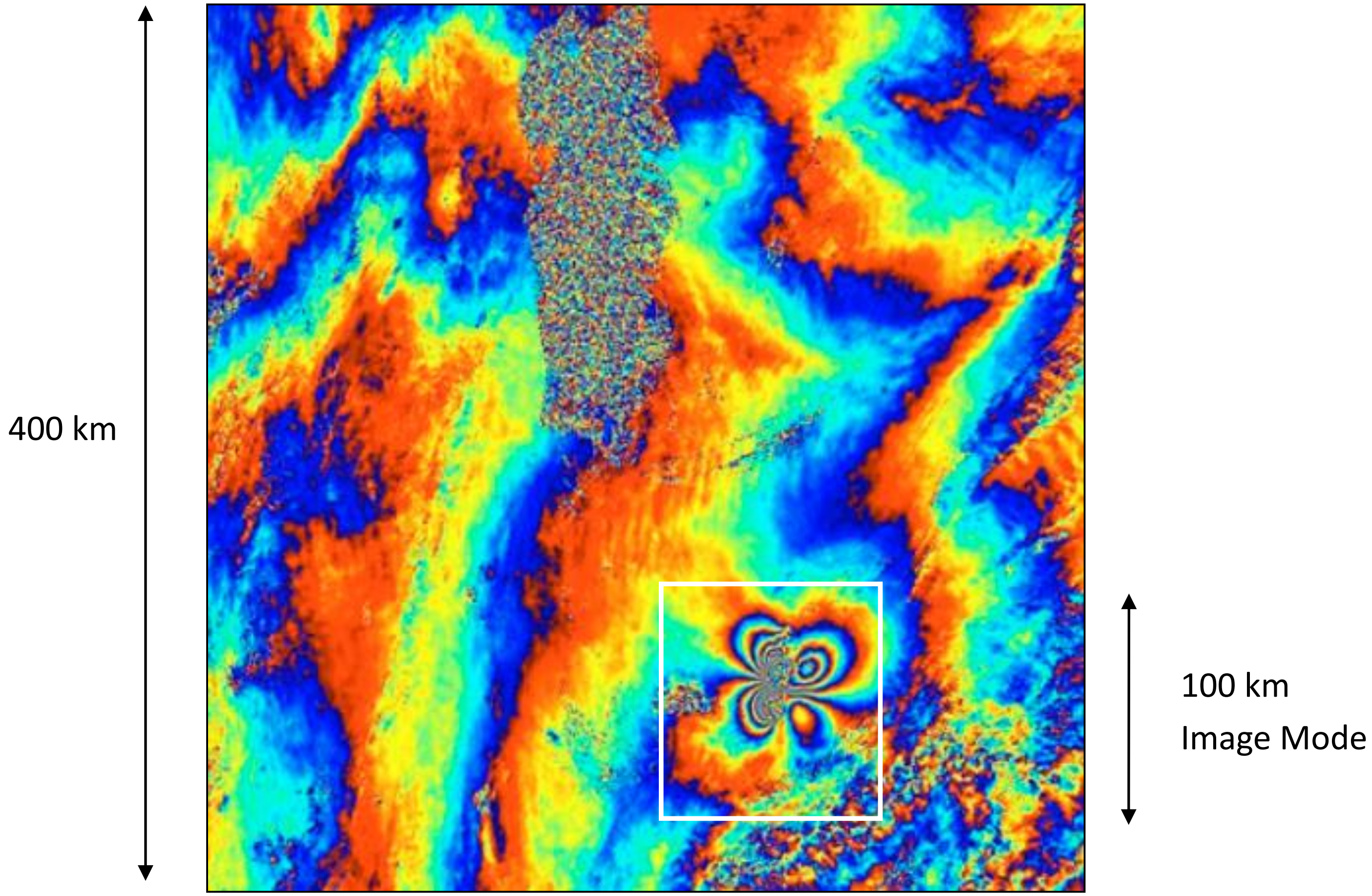


Coherence
Mean Intensity
Intensity Change



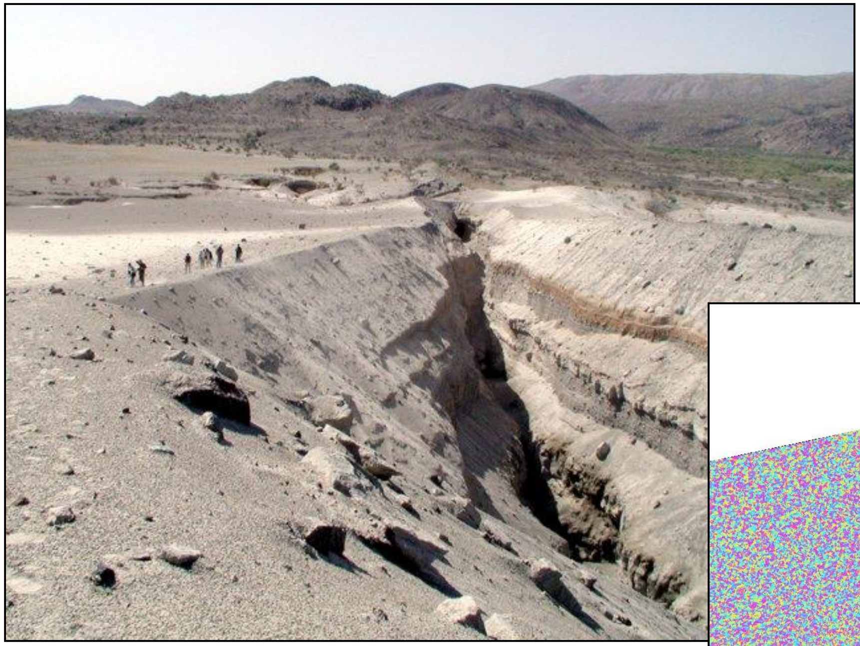
Senegal

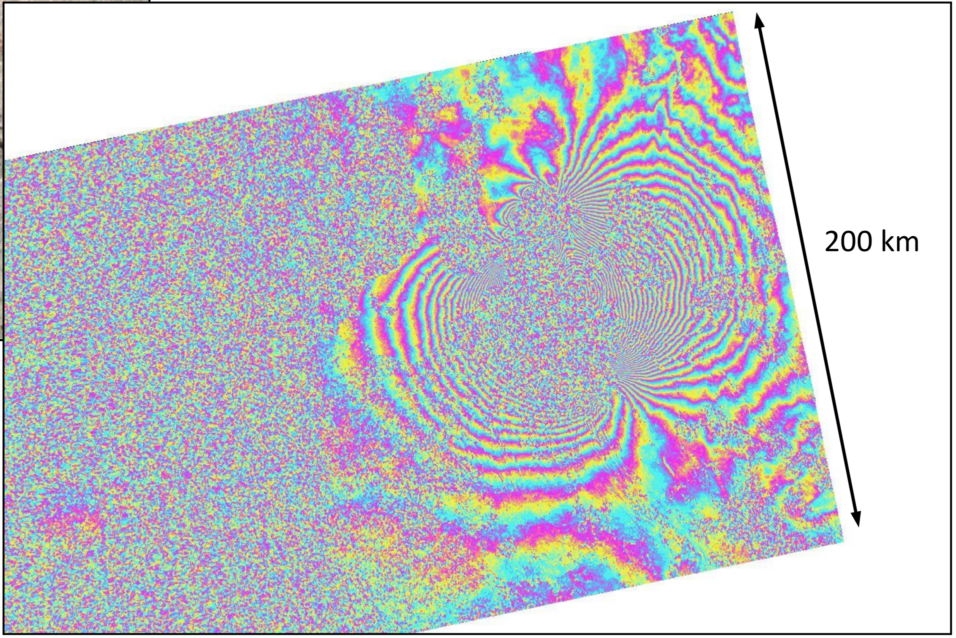
ScanSAR Differential Interferometry – ENVISAT ASAR Wide Swath



Bam, Iran

ScanSAR Differential Interferometry – ENVISAT ASAR Wide Swath





Ethiopia

Interferometric Stacking Module

The Interferometric Stacking module integrates point-based (PS-like) and area-based (SBAS-like) techniques for the processing of interferometric stacks. This combined approach allows analyzing deformation phenomena affecting both extended area (e. g. natural features) and localized structures (e. g. man made features), related to natural or man-induced phenomena (e. g. volcanic or seismic activity, landslides, subsidence, building failures, etc.).

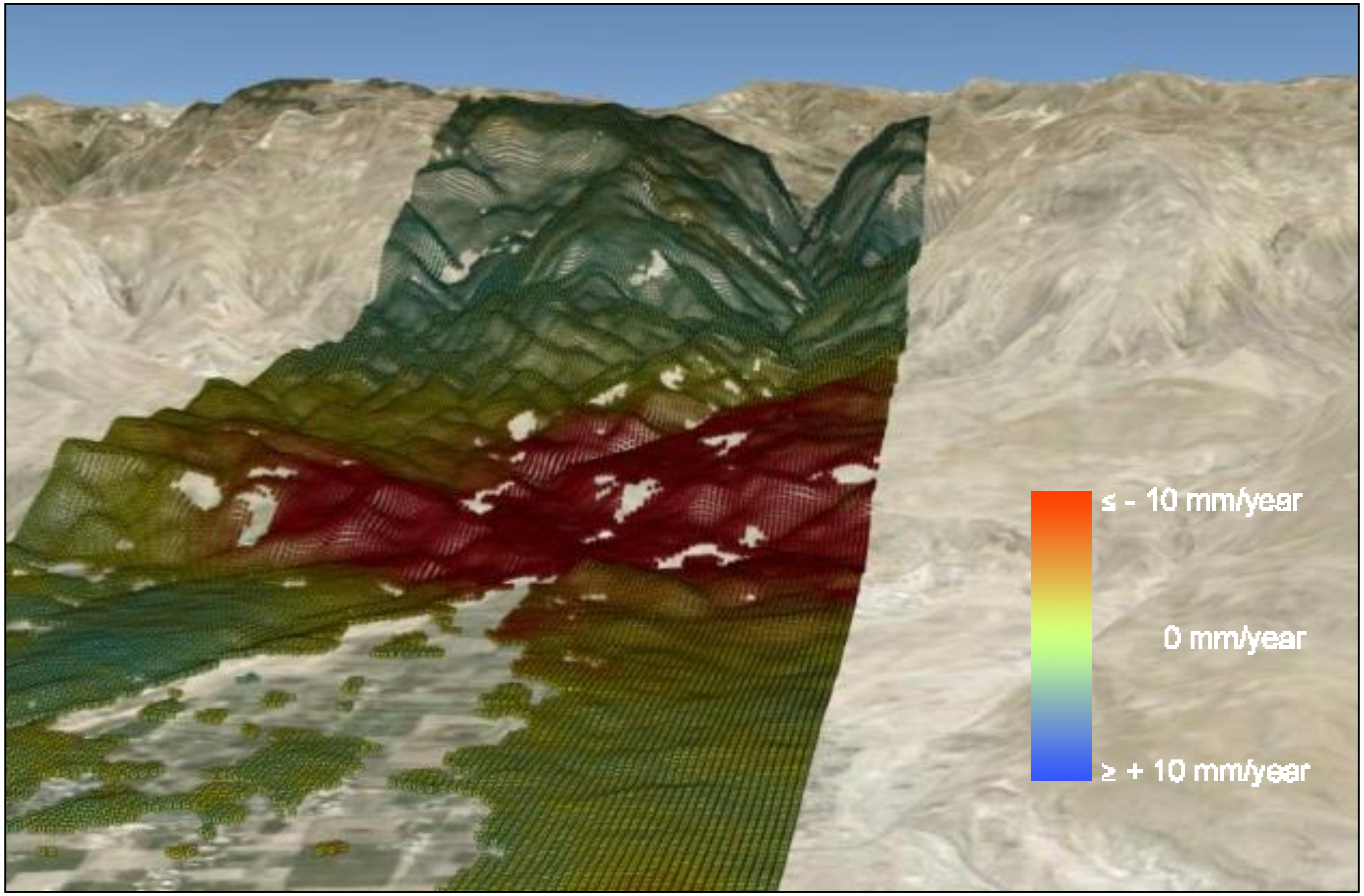
- <u>Small Baseline Subset (SBAS)</u>
  Is a complementary method that exploits differential SAR interferometry techniques to analyse stacks of SAR acquisitions to extract small deformations over large areas, where no point targets might be identified but large, correlated displacements occur over natural targets.

- <u>Persistent Scatterers (PS)</u>
  Enables to detect very small displacements (mm scale) and to infer the deformation velocity - and its variation over the time - in particular for very stable (man-made) reflectors that might have independent displacements respect to the surrounding areas.

Interferometric Stacking Module

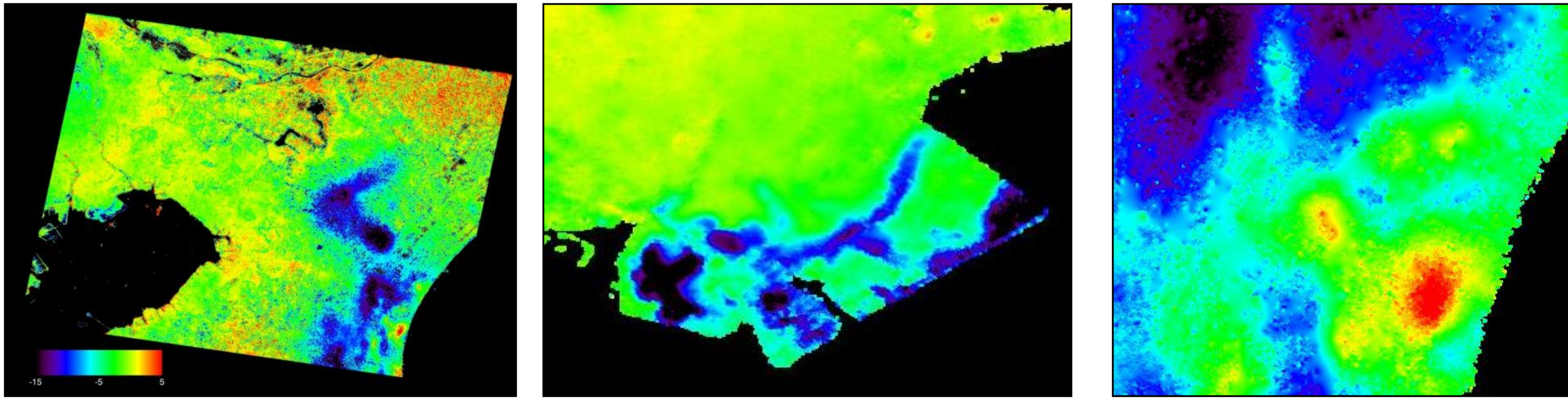
PS - Point-based	SBAS - Area-based
Independent, incorrelated motions	At best spatially correlated motions
Pixelwise continuous time series	Possibility of handling time seriers with temporal holes
Time interval between two acquisitions limited by displacement rate	Time interval between two acquisitions limited by temporal decorrelation
Very accurate on PS	Slightly less accurate
Linear displacements favoured	Parametric models possible Non-parametric modeling possible

SBAS based on 30 ENVISAT ASAR Image Mode data

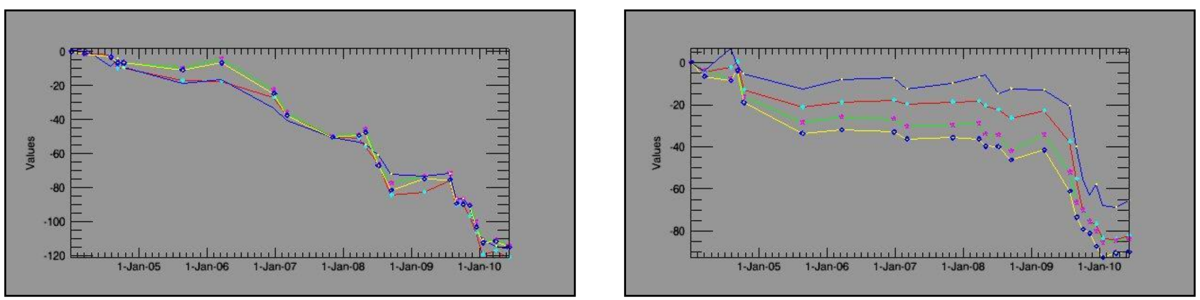


Middle East

SBAS based on ALOS PALSAR-1 data

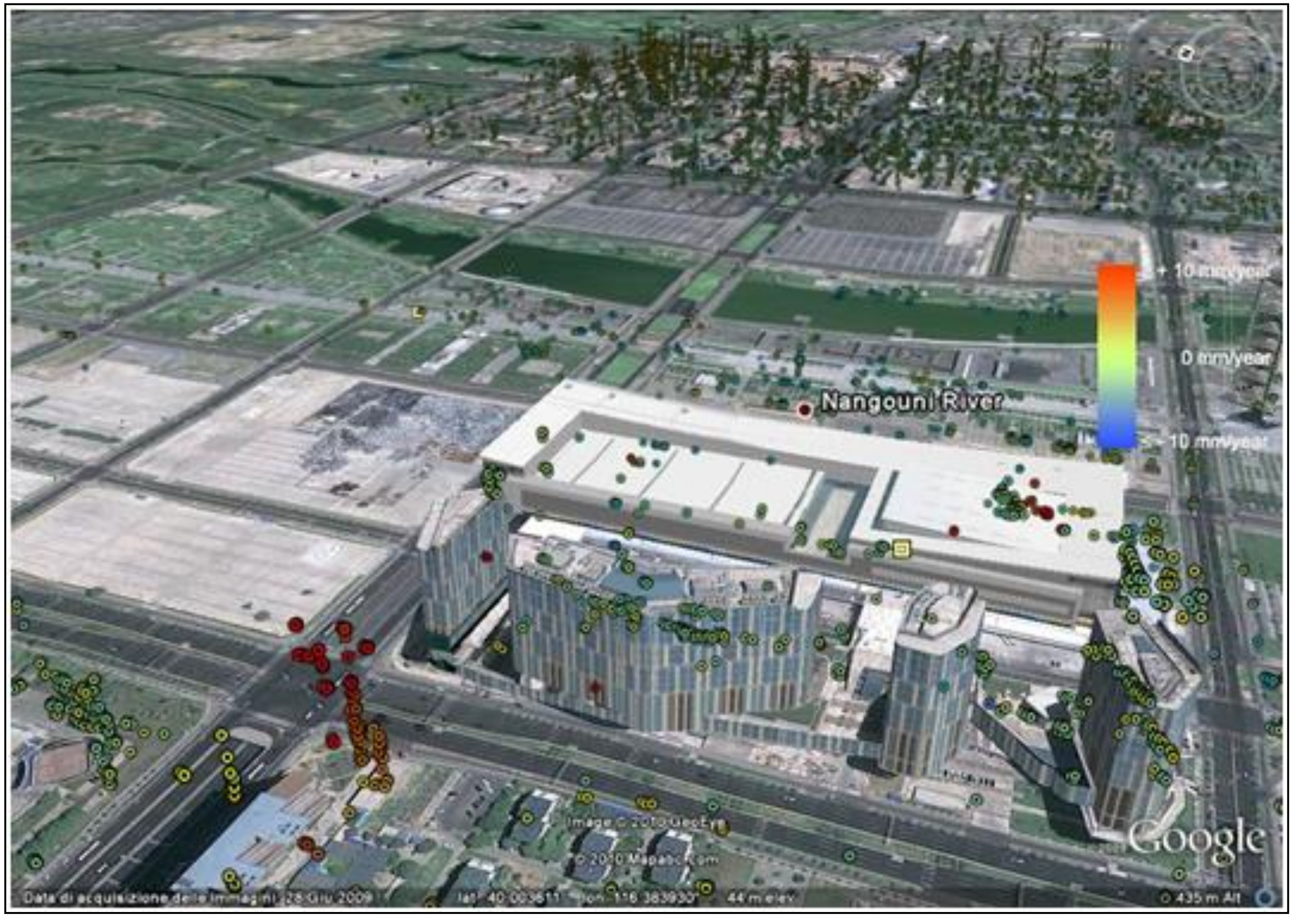


Average displacement rate (color scale between -15 and +5 mm/year) of an area around the cities of Tokyo and Chiba, Japan, derived from ALOS PALSAR-1 data in the period 2006-2010. Whole area (left), a region of terrain compaction over landfill (center), uplift due to too much water injection after natural gas extraction (right).



Location time series of groups of terrain points in a same area showing different temporal behaviors, as obtained from Interferometric Stacking techniques . Points showing linear trends (left), and points with significant non-linearities (right); vertical scale in [mm].

PS based on 25 ENVISAT ASAR Image Mode data



Beijing

Polarimetry and Polarimetric Interferometry Module

The processing capabilities of **SAR Polarimetry** are:

- Polarimetric Calibration Matrix

  Polarimetric calibration allows to minimize the impact of non ideal behaviours of a full polarimetric SAR acquisition system, to obtain an estimate of the scattering matrix of the imaged objects as accurate as possible from their available measurement. Polarimetric calibration is performed based on defined calibration matrixes.

- Polarimetric Signature

  This function provides an estimate of the polarimetric signature of a point-target-like object, whose location is specified either in terms of its range and azimuth indexes within a slant-range acquisition, or through its known cartographic coordinates.

- Polarimetric Synthesis

  The availability of a full polarimetric acquisition, for example based on a linearly polarized base, allows to synthesize any desired elliptical polarization. Starting from a set of full polarimetric linearly polarized Single Look Complex (SLC) data, this module allows to synthesize a new set of SLC data in a desired orthogonal basis, either circular, linear rotated of 45 degrees or generic elliptical of user defined orientation and ellipticity.

Polarimetry and Polarimetric Interferometry Module

- Polarimetric Features

  This function performs the computation of conventional polarimetric features - among others the Linear Depolarization Ratio, the Polarimetric Phase Difference, and the Polarization HH-VV Ratio - based on the scattering matrix.

- Pauli Decomposition

  The Pauli coherent decomposition provides an interpretation of a full polarimetric SLC data set in terms of elementary scattering mechanisms: sphere/plate/trihedral (single- or odd-bounce scattering), dihedral oriented at 0° (double- or even-bounce) and diplane oriented at 45° (qualitatively related also to volume scattering).

- Entropy-Anisotropy-Alfa Decomposition

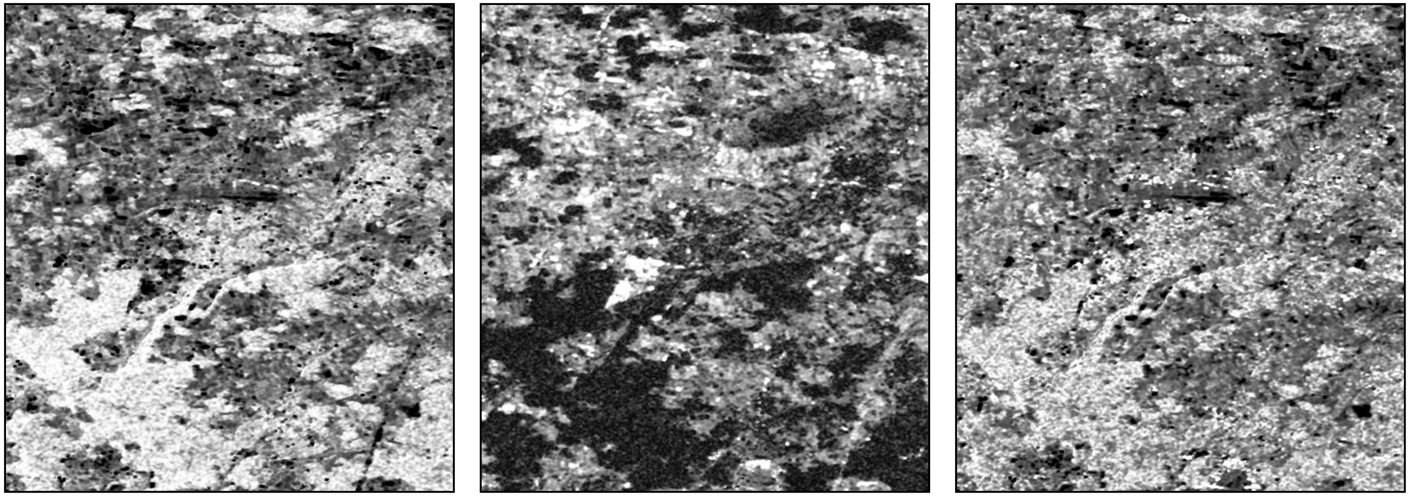
  The Entropy-Anisotropy-Alpha decomposition performs an eigen-decomposition of the coherency matrix of a full polarimetric SLC data set. The output aree:

  - Entropy - it is related to degree of randomness of the scattering process
  - Anisotropy - it measures the relative importance of 2nd and 3rd eigenvalue
  - Alpha - it relates the type of scattering mechanism

Polarimetry and Polarimetric Interferometry Module

- Entropy-Anisotropy-Alfa Classification

  It performs an unsupervised classification of the results of a previous Entropy-Anisotropy-Alpha decomposition step, identifying the main scattering type of every pixel in the target area.



Entropy-Anisotropy-Alfa Decomposition based on ALOS PALSAR-1 PLR data

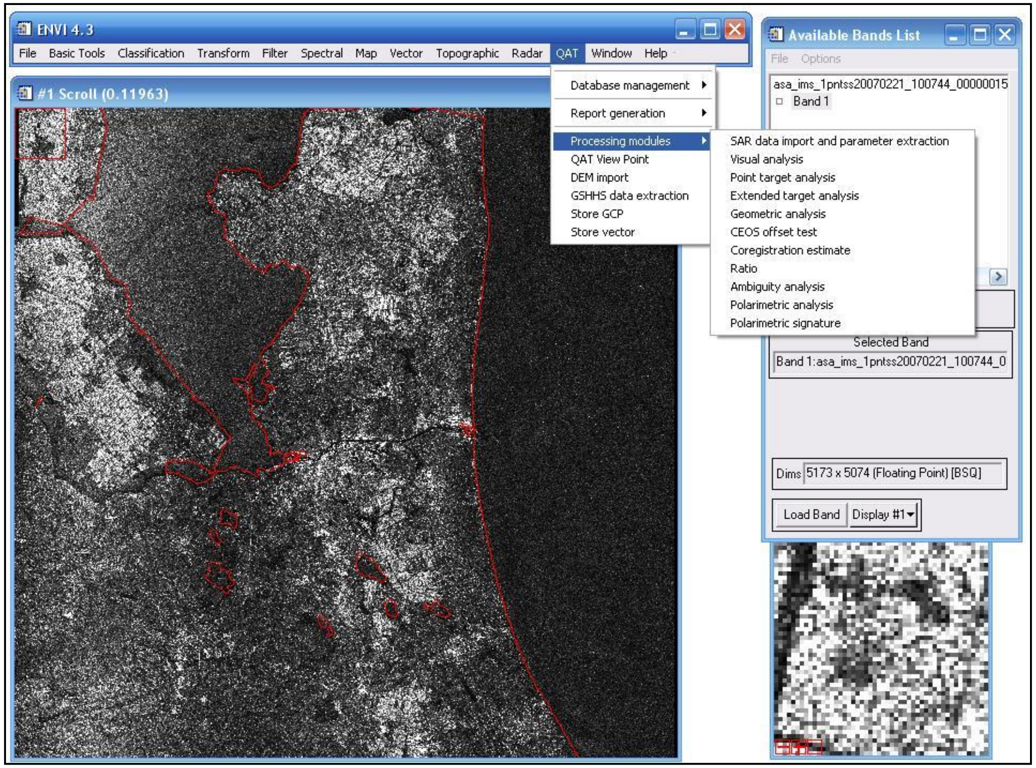
Polarimetry and Polarimetric Interferometry Module

The processing capabilities of **Polarimetric SAR Interferometry** are:

- Single Look Complex Coregistration
  This function performs an unsupervised classification of the results of a previous Entropy-Anisotropy-Alpha decomposition step, identifying the main scattering type of every pixel in the target area.
- Polarimetric Phase Difference / Interferogram Generation
  This function performes i) the Polarimetric Phase Difference using the HH and VV polarization of the same acquisition, and ii) it generates interferograms using the same polarization of the PolInSAR pair.
- Polarimetric / Interferometric Coherence
  This function generates correlation/coherence images based on Polarimetric Phase Difference / Interferogram products.
- Coherence Optimization
  This function estimates the main scattering mechanisms of a full polarimetric pair of linear acquisitions, identifying those mechanisms that correspond to the highest value of interferometric coherence. The corresponding interferograms and coherence maps are provided as result.

Quality Assessment Tool

In order to quantitatively assess the geometric, radiometric, and polarimetric quality of SAR products, a Quality Assessment Tool (QAT) based on a solid methodology is proposed. The overall architecture of the QAT system supports the quality assessment for ENVISAT ASAR (IM,AP,WS) and RADARSAT-1 and -2 (FB,SB,WB,EB,ScanSAR) data.



Quality Assessment Tool

Following quality parameters and assessment procedures are supported:

- Background removal and image interpolation
- Impulse Response Function measurements
    - Spatial resolution in range and azimuth
    - Peak Side Lobe ratio
    - Range and azimuth Peak Side Lobe ratio
    - Spurious sidelobe ratio
    - Integrated Side Lobe Ratio
    - Derivation of sigma nought and radiometric calibration
    - Sigma nought derivation for ASAR ground range projected products
    - Sigma nought derivation for ASAR single complex slant range projected products
    - Beta nought for derivation or RADARSAT-1 detected products
    - Beta nought derivation for RADARSAT-1 single look complex products
    - Conversion from beta nought to sigma nought
- Calibration constant determination
- Radiometric analysis
    - Radiometric accuracy
    - Radiometric resolution
    - Equivalent Number of Looks
    - Radiometric stability
    - Noise equivalent sigma nought

Quality Assessment Tool

- Ambiguity analysis
    - Azimuth ambiguity location offset
    - Range ambiguity location offset
    - Point target ambiguity ratio
- Geometric analysis
    - Level 1 products geocoding
    - Absolute location accuracy
    - Sampling Window Start Time bias
    - Ground Control Point geocoding and residual analysis
    - Swath width and position
    - Channel co-registration
- Multi-temporal co-registration
- Ratio
- Polarimetric analysis
    - Polarimetric Phase Difference and polarimetric coherence
    - Polarimetric signature

Quality Assessment Tool

The Quality Assessment Tool is composed by three logical parts:

- All what concerns Graphical User Interface (GUI), data, and information display is integrated within the ENVI® environment (Window® and Linux®). This solution allows to obtain professional tools for data visualisation both for raster and vector data in standard formats, and it enables to exploit the existing basic analysis tools already available within ENVI®. This layer has the purpose of driving the execution of the different Quality Assessment funcions in an interactive way as well as displaying their results, in terms of images, textual data and plots.
- All modules related to initial data import and assessment are available as executable modules, originally written in C++ and that may be invoked both through the mentioned GUI and as command-line modules. Data import, in particular, has the purpose of interfacing the QAT system with SAR data originating from different platforms, and hence stored and delivered in different formats. The data stored in these formats are analysed during import phase, all the necessary parameters are extracted and stored in a XML file with common syntax (documented in the delivered documentation). The binary data (image products) are stored in a plain matrix (BIL) file, and a correspondent .hdr file is generated, consistent with ENVI® specifications, to allow the direct display of the binary data within the ENVI® environment. All Quality Assessment functions deal directly with the data imported into a common meta-format.
- The third layer of database has the purpose of intercepting all the results of the Quality Assessment functions and storing them within a history database, as well as storing reference and nominal values for important parameters. A part of the database is dedicated to storing information concerning Ground Control Points to be reused during a long-time assessment of SAR data quality over a same reference test-site.

- Key Features

- **Airborne SAR**
  - » Proper handling of motion compensated data
  - » Height dependent coregistration
  - » Proper handling of azimuth-varying Doppler spectrum

- **Spotlight**

  TerraSAR-X, COSMO-Skymed, SAR-Lupe
  - » Height dependent coregistration
  - » Proper handling of azimuth-varying Doppler spectrum

- **ScanSAR interferometry**

  ASAR WS
  - » Proper handling of azimuth-varying Doppler spectrum

- **Cross-mode**

  PALSAR FBS – FBD – PLR, ASAR WS – IM, ERS-2 – ASAR
  - » Processing optimised for all different cases

- Key Features

- Phase-preserving SAR focussing: high precision SLC data can be obtained from SAR raw data, starting from either Image mode or ScanSAR products, using an w-k algorithm.
- Automatic coregistration of multi-temporal SAR or optical image stacks: using cross-corrrelation techniques, pixel-accuracy is obtained without need of manual selection of corresponding points.
- Multi-temporal speckle filter: when several SAR acquisitions are available over a same area, this additional unique filtering functionality allows to obtain high speckle reduction while conserving all spatial and temporal information.
- A dedicate SAR filtering module, based on the most advanced Gamma and Gaussian distributed scene models, is suitable for products such as SLC, PRI, Multitemporal data sets, etc.
- One-step coherence maps computation: all processing steps necessary to generate such products can be performed as just one operation.
- Rigorous geocoding of SAR data based on Range-Doppler equations. Accurate terrain correction can be performed when a DEM is available; radiometric correction is performed by rigorously considering the radar equation.

- Key Features

- Identification of Ground Control Points in the SAR image is supported by an archive.
- Radiometric and geometric calibration of optical data can be performed during geocoding, based on DEM information when available.
- A wide number of cartographic reference systems is available for the geocoded products; the user can extend it by providing all necessary parameters in easily accessible ASCII files.
- Batch processing: long sequences of processing steps can be collected in one batch command and run as a single operation. Script programming is available as well.
- The interferometric processing chain can be applied to both medium resolution (e.g. ASAR Wide Swath products) and high resolution (e.g. ASAR Image mode products) data.
- Tailored and dedicated data mosaicing routines are developed to join at the best amplitude as well as DEM images.
- High accuracy DEMs can be generated using the interferometric module.
- Differential interferograms can be generated using the interferometric module to estimate small terrain movements (in the order of few millimetres).

- Key Features

- External DEMs can be imported; USGS GTOPO-30 and SRTM-3 world-wide DEMs can be automatically extracted and mosaiced over the area of interest by simply inputting the reference slant range or geocoded image.
- Both Windows and Linux operating systems are supported.
- Integration in well-known GIS or image processing environments, allowing the user to exploit a wide base of tools together with the specific capabilities of SARscape®. The user can select the preferred environment suiting at best with his applications, accessing the same processing routines and even sharing the same data between the two platforms.
- Standard open formats are used for all generated products.