

OPTICALscape®

The logo graphic for OPTICALscape is a tilted grid of squares. The top square is blue, the middle-left square is purple, the bottom square is cyan, and the middle-right square is purple with a registered trademark symbol (®). The grid lines are thin and black.

The Earth Observation information gateway

Spaceborne stereo-optical module

This module - developed in collaboration with 4DiXplorer - supports the processing of spaceborne stereo-optical data from radiometric processing, image orientation to automatic Digital Elevation Model (DEM) and ortho-image generation.

Key features of this module are:

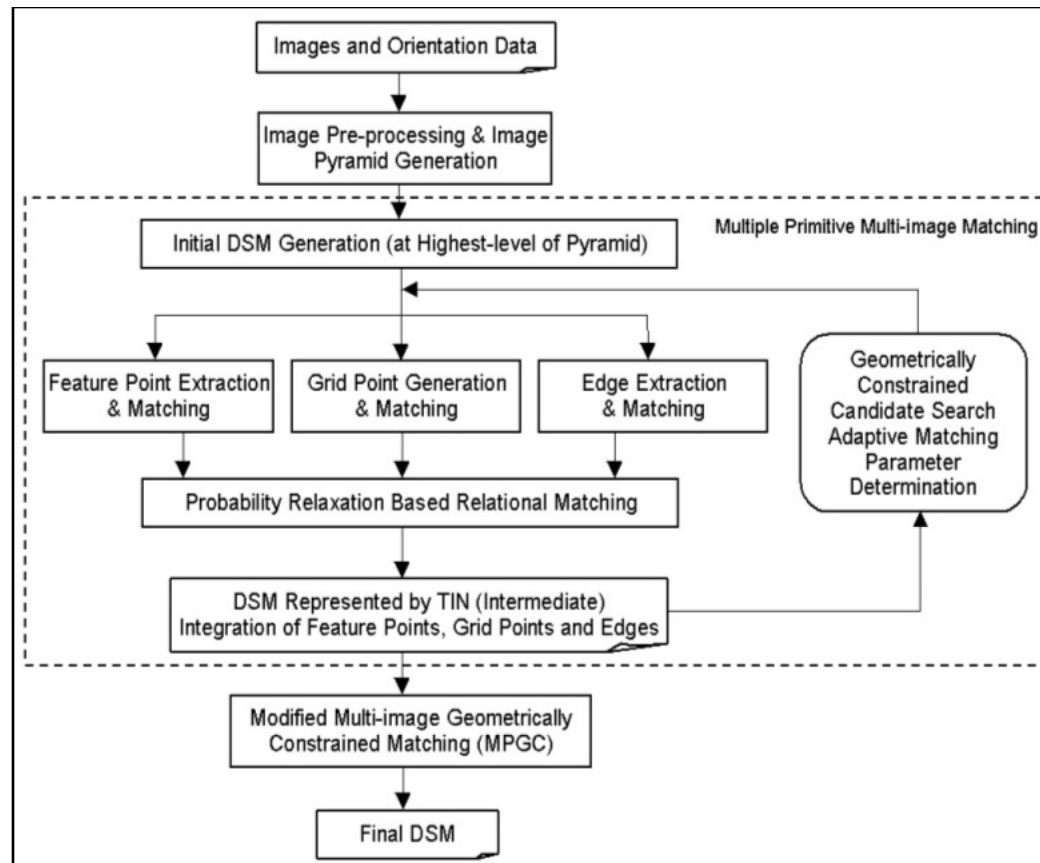
- DEM generation, which is based on an advanced matching algorithm. The approach uses a coarse-to-fine hierarchical solution with an effective combination of several image matching algorithms and automatic quality control. Moreover, the new characteristics provided by the latest imaging systems, i.e. the multiple-view terrain coverage and the high quality image data, are also efficiently utilized.
- The DEM fusion by considering spaceborne sensor's characteristics. The proposed functionality supports the fusion of:
 - stereo-optical - InSAR;
 - stereo-optical - stereo-optical;
 - InSAR - InSAR.

Spaceborne stereo-optical – Available functionalities

- Radiometric processing
- Sensor and trajectory models
- Orientation of single, stereo models, triplets and blocks
- Online quality control and error analysis
- Ground Control Point and Tie Point measurement
- Derivation of quasi-epipolar images for stereo mapping and feature collection
- Automated DEM generation
- Generation of ortho-rectified images

- DEM fusion

Spaceborne stereo-optical



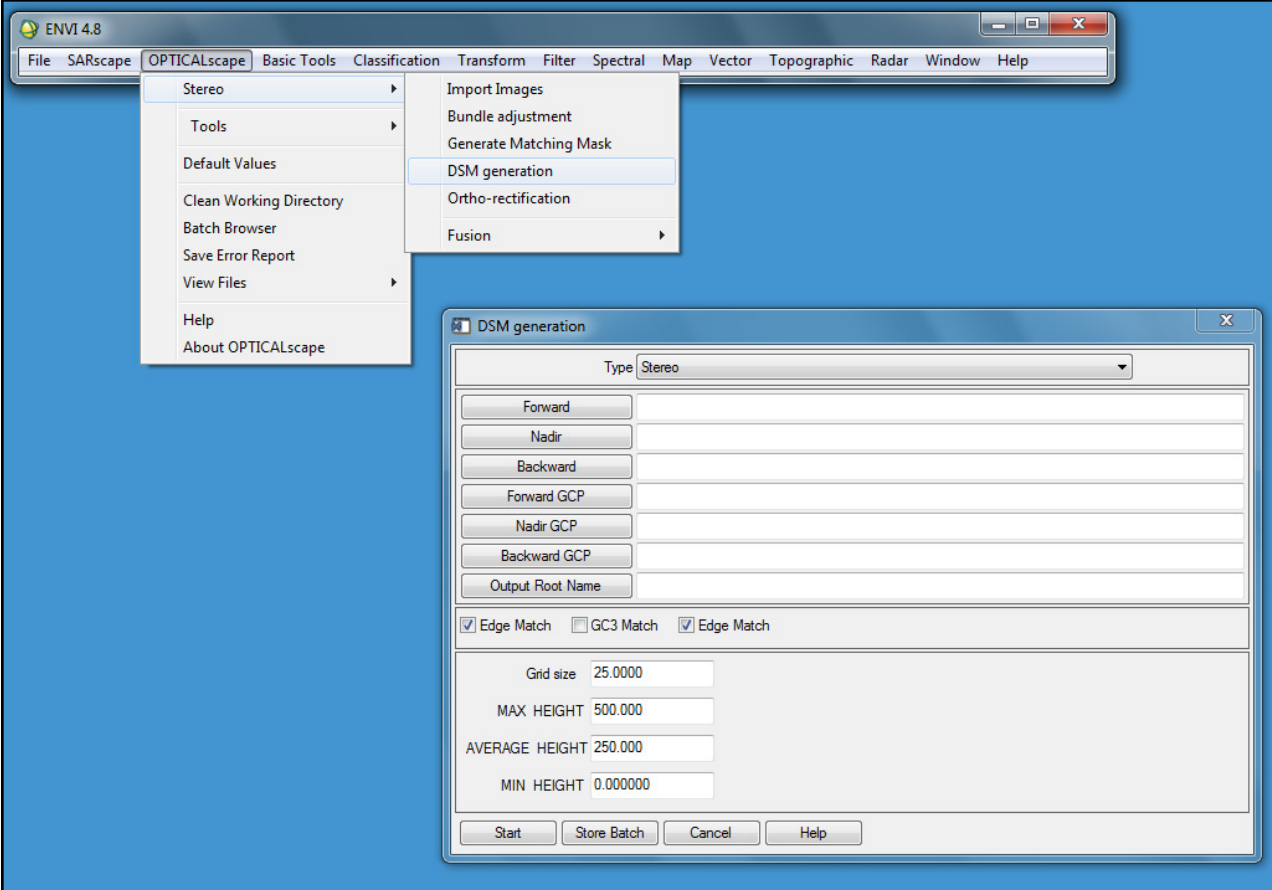


Spaceborne stereo-optical – Supported sensors

CARTOSAT-1/2	2.5 m
SPOT-5	2.5 m / 5x10 m
Ikonos-2	1.0 m
QuickBird-2	0.70 m
Pléiades	0.70 m
WorldView-1/2	0.50 m
GeoEye-1	0.40 m



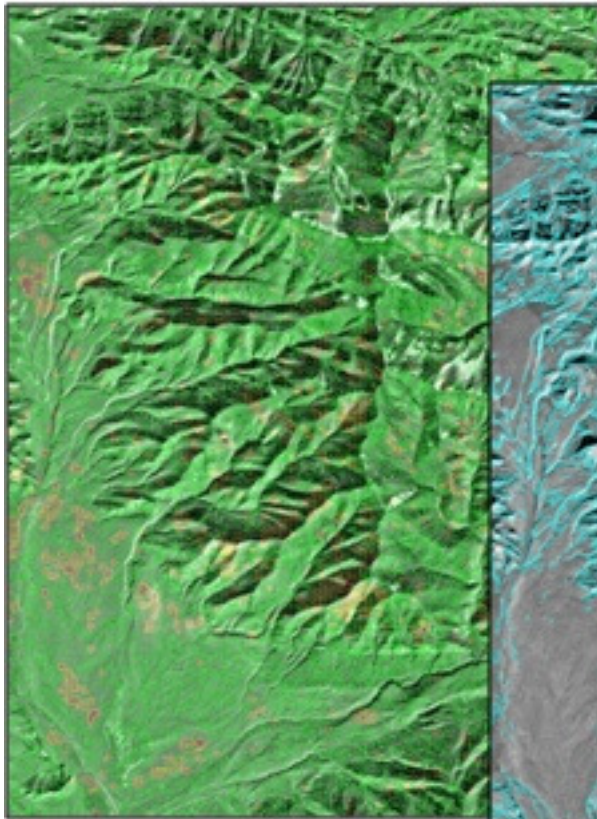
Spaceborne stereo-optical – Interface



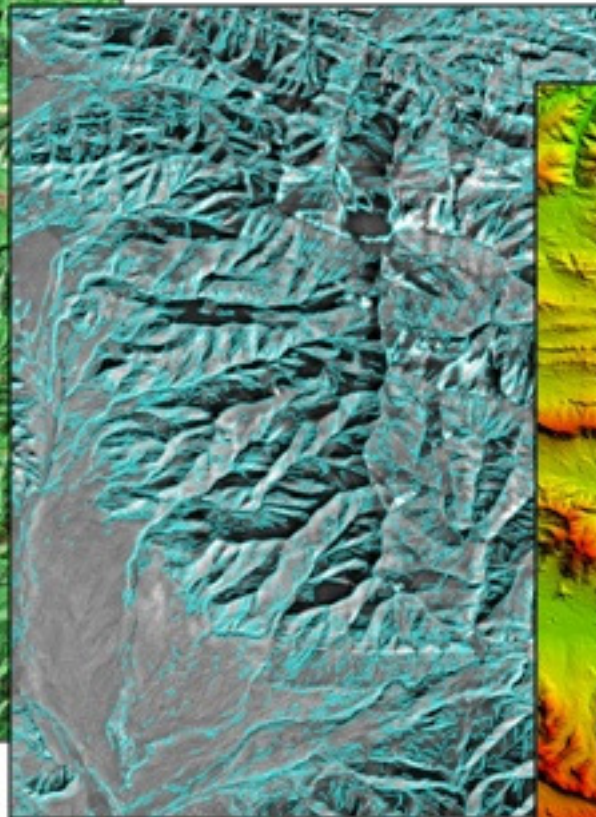
The screenshot displays the ENVI 4.8 software interface. The 'OPTICALscape' menu is open, showing options like 'Stereo', 'Tools', 'Default Values', 'Clean Working Directory', 'Batch Browser', 'Save Error Report', 'View Files', 'Help', and 'About OPTICALscape'. The 'Stereo' submenu is also visible, containing 'Import Images', 'Bundle adjustment', 'Generate Matching Mask', 'DSM generation', 'Ortho-rectification', and 'Fusion'. The 'DSM generation' dialog box is open, showing the following settings:

- Type: Stereo
- Forward: [Empty field]
- Nadir: [Empty field]
- Backward: [Empty field]
- Forward GCP: [Empty field]
- Nadir GCP: [Empty field]
- Backward GCP: [Empty field]
- Output Root Name: [Empty field]
- Edge Match GC3 Match Edge Match
- Grid size: 25.0000
- MAX HEIGHT: 500.000
- AVERAGE HEIGHT: 250.000
- MIN HEIGHT: 0.000000
- Buttons: Start, Store Batch, Cancel, Help

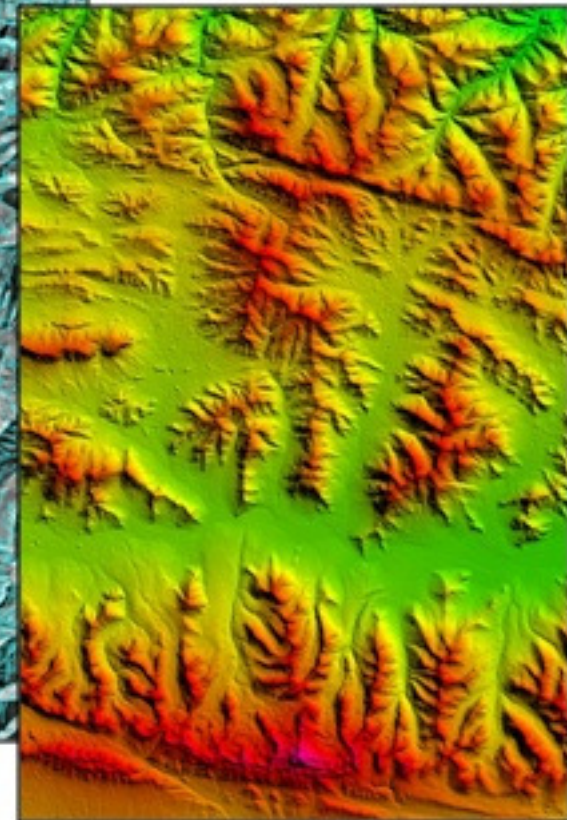
Spaceborne stereo-optical – SPOT-5 HRS



Points

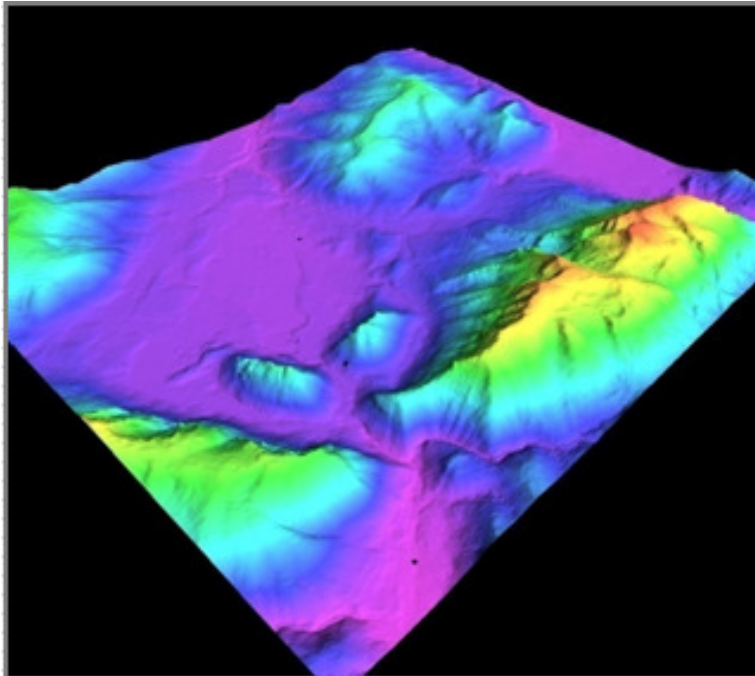


Edges

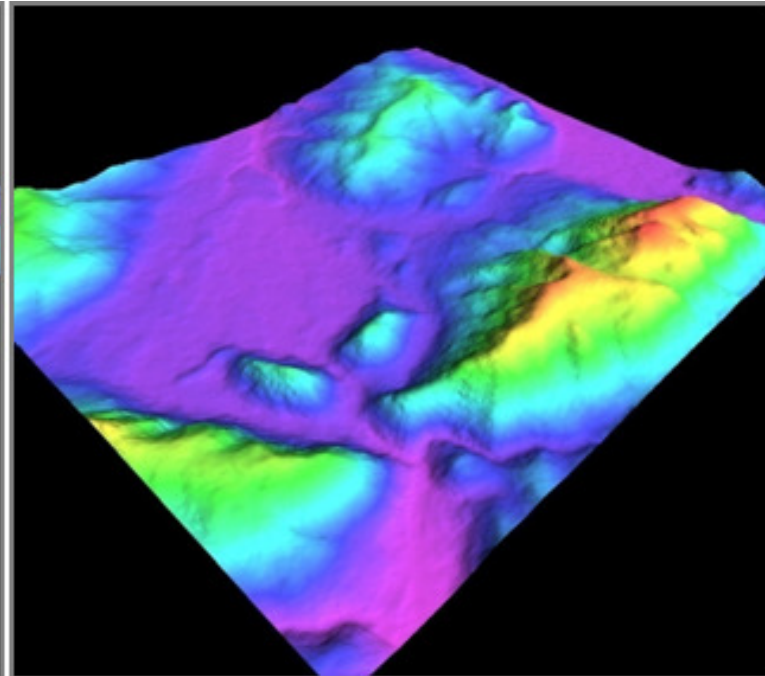


DEM

Spaceborne stereo-optical – SPOT-5 HRS

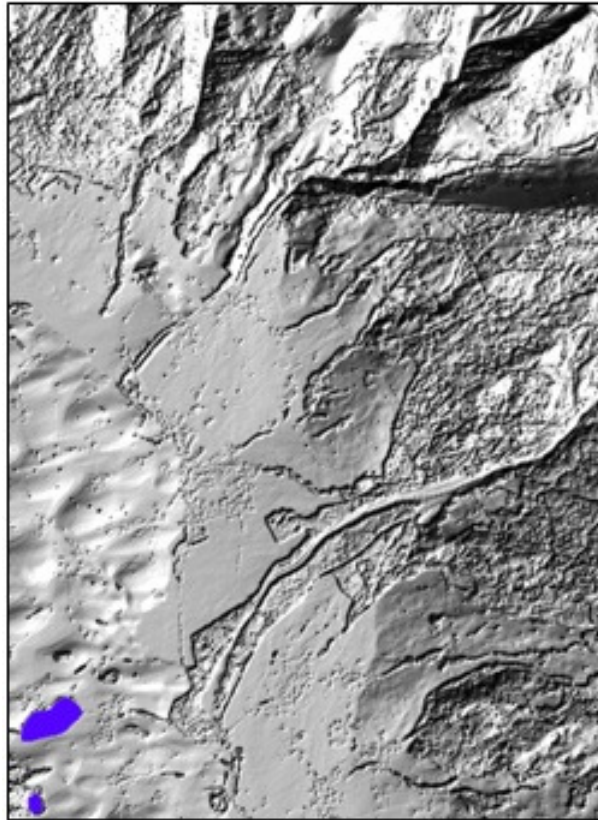


Reference DSM (5 m)

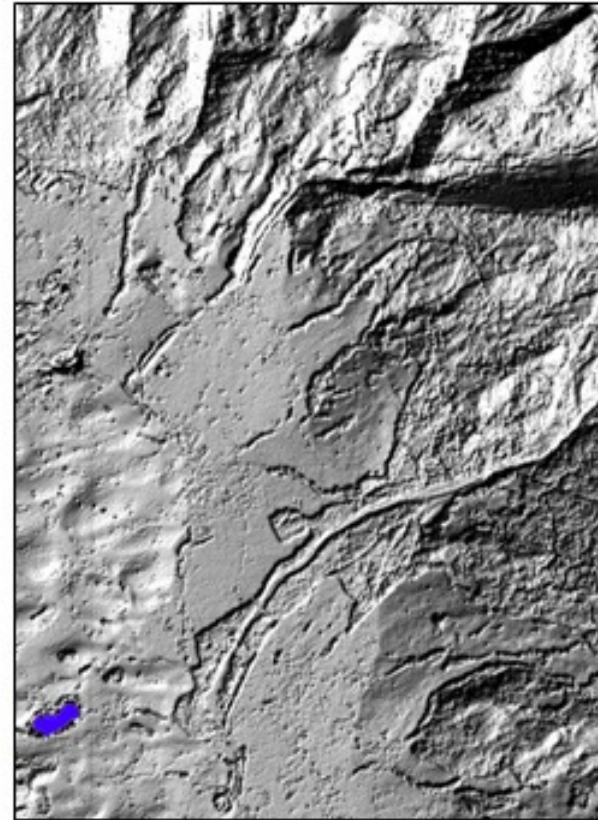


SPOT-5 DSM (25 m)

Spaceborne stereo-optical – IKONOS and comparison with LIDAR

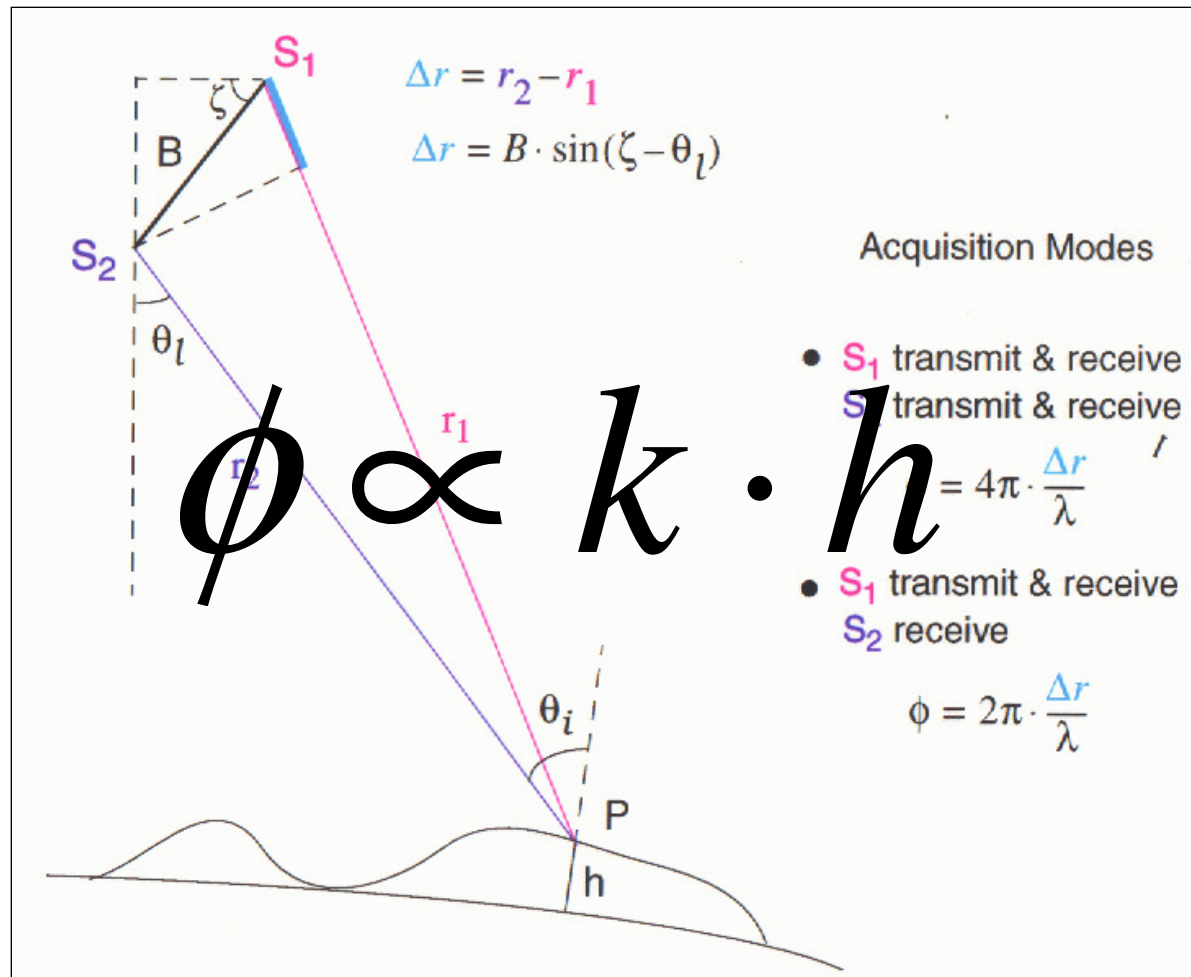


LIDAR DSM (2 m)



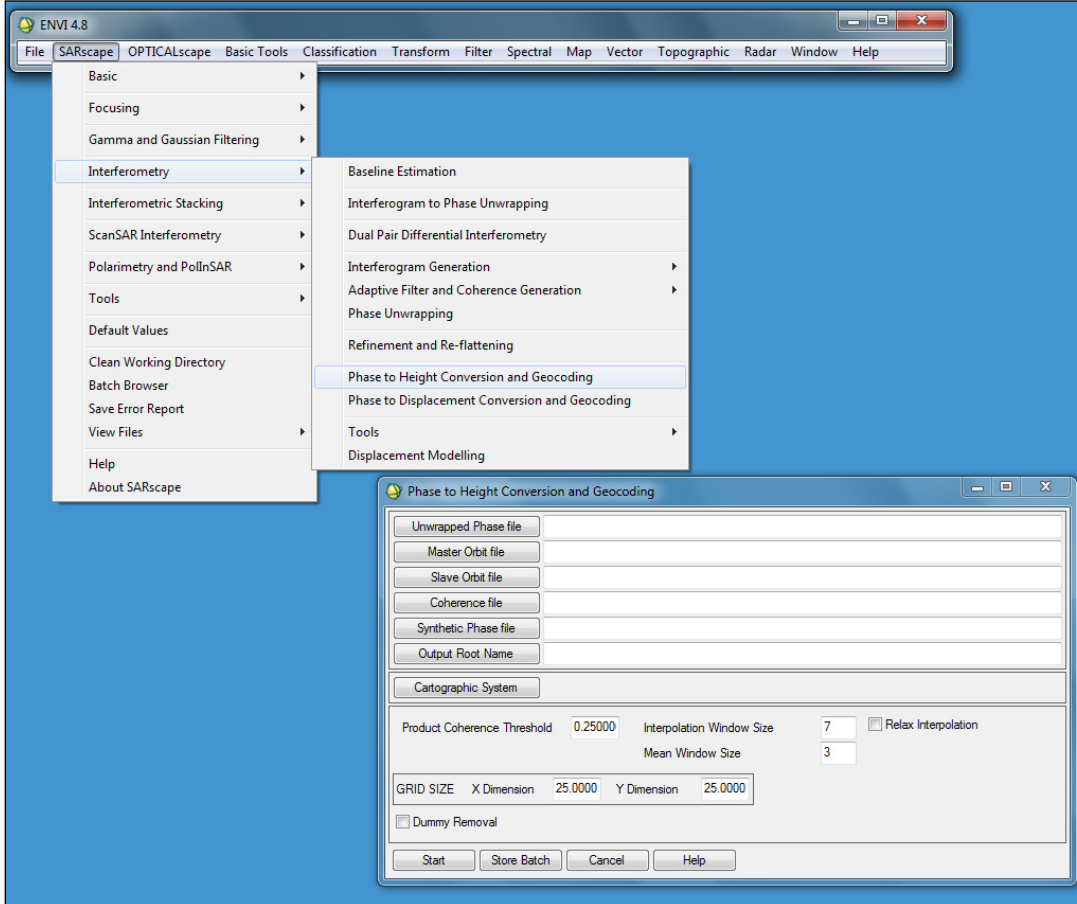
IKONOS DSM (5 m)

Synthetic Aperture Radar Interferometry (InSAR) – Principle





Interferometry Module – Interface



The screenshot displays the ENVI 4.8 software interface with the Interferometry menu open. The 'Phase to Height Conversion and Geocoding' option is selected, which has opened a corresponding dialog box. The dialog box contains the following fields and controls:

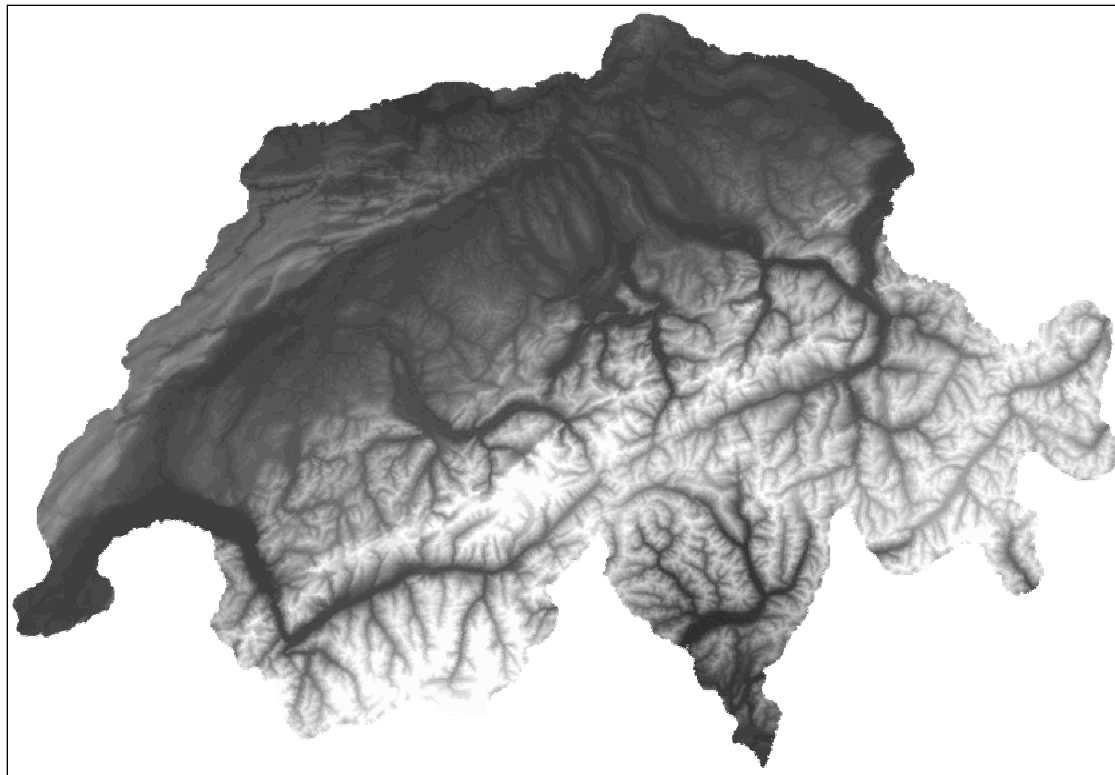
- Unwrapped Phase file: [Empty text field]
- Master Orbit file: [Empty text field]
- Slave Orbit file: [Empty text field]
- Coherence file: [Empty text field]
- Synthetic Phase file: [Empty text field]
- Output Root Name: [Empty text field]
- Cartographic System: [Empty dropdown menu]
- Product Coherence Threshold: 0.25000
- Interpolation Window Size: 7
- Relax Interpolation:
- Mean Window Size: 3
- GRID SIZE: X Dimension 25.0000, Y Dimension 25.0000
- Dummy Removal:
- Buttons: Start, Store Batch, Cancel, Help



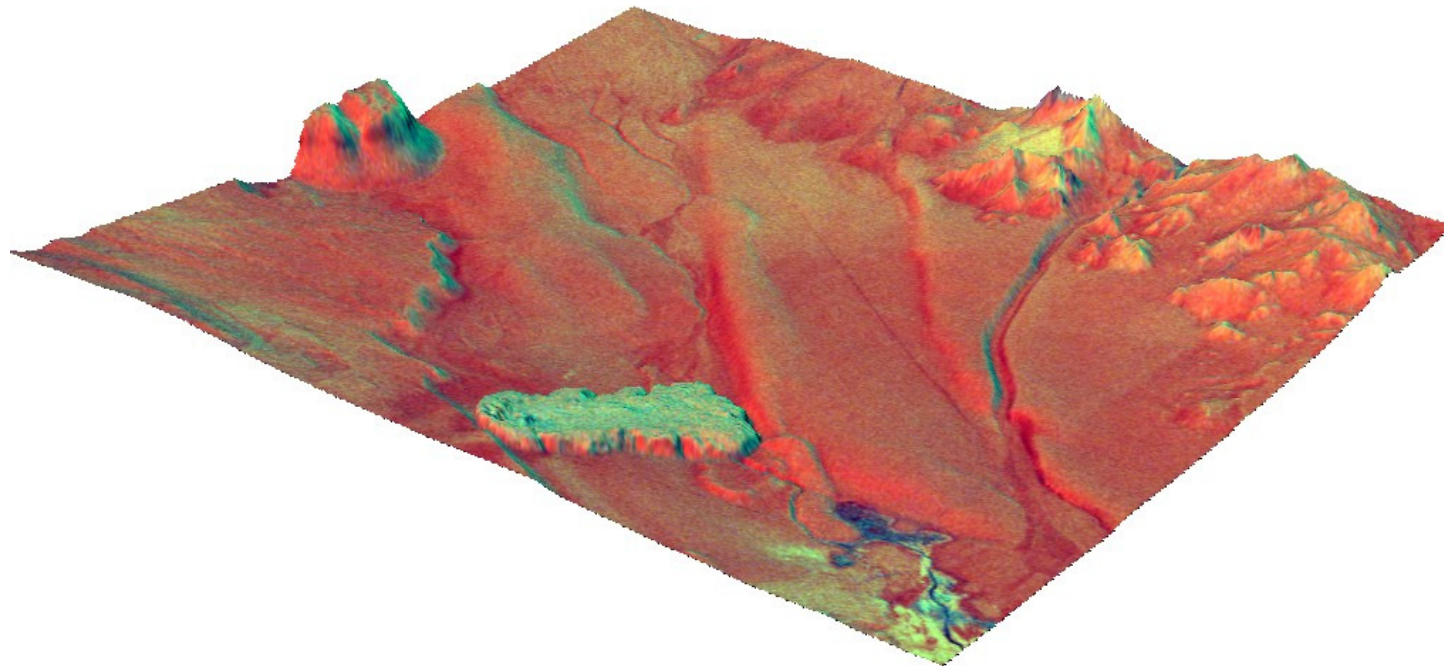
SAR Interferometry Module – Supported systems

ERS-1/2	25m	C-band
RADARSAT-1	up to 10m	C-band
ENVISAT ASAR	up to 15m	C-band
ALOS PALSAR-1	up to 8m	L-band
TerraSAR-X-1/2	up to 3m	X-band
RADARSAT-2	up to 3m	C-band
COSMO-SkyMed-1/2/3/4	up to 1m	X-band
RISAT-1	2m to 50m	C-band
Sentinel-1 A/B	up to 5m	C-band
ALOS PALSAR-2	up to 3m	L-band

Spaceborne SAR Interferometry – ERS-Tandem, 25m



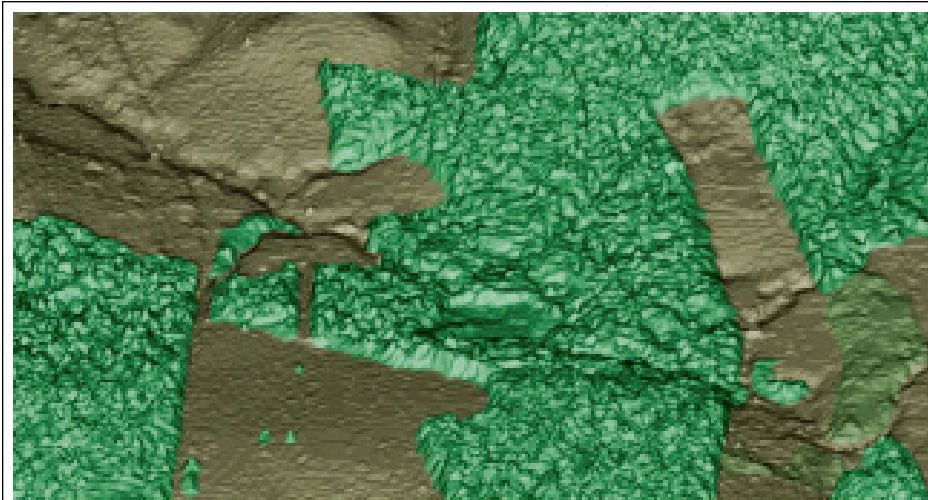
Spaceborne SAR Interferometry – TerraSAR-X-1, 3m



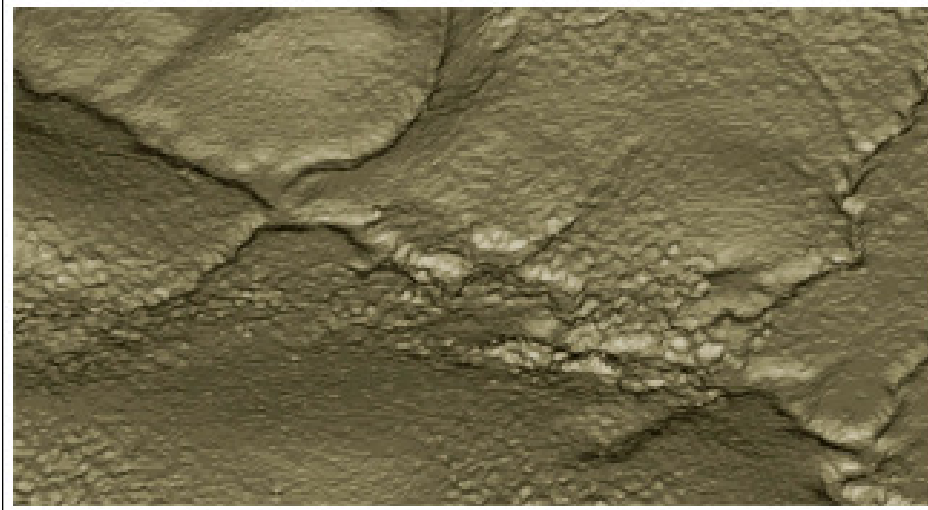
Spaceborne SAR Interferometry – Cosmo-SkyMed-1/2, 1m



Airborne SAR Interferometry – Digital Surface and Terrain Model



**Digital Surface Model
X-band**



**Digital Terrain Model
P-band**

OrbiSAR-1

Stereo-optical vs. SAR interferometry

	interferometry	stereo-optical
Influenced by clouds	NO	YES
Influenced by atmospheric water vapour	YES	NO
Influenced by sun illumination	NO	YES
Reliable height estimation on poorly textured areas	YES	NO
Accurate on edge features	NO	YES
Layover effects	YES	NO
Surface height	YES	YES
Terrain height	YES	NO

Precision, Reliability, Weighting, Feature maps

Precision

estimated by exploiting

- baseline
- wavelength
- interferometric coherence
- local incidence angle (slope and aspect wrt the sensor)
- spatial ground resolution

Reliability

estimated by exploiting

- cross-correlation
- slope and aspect

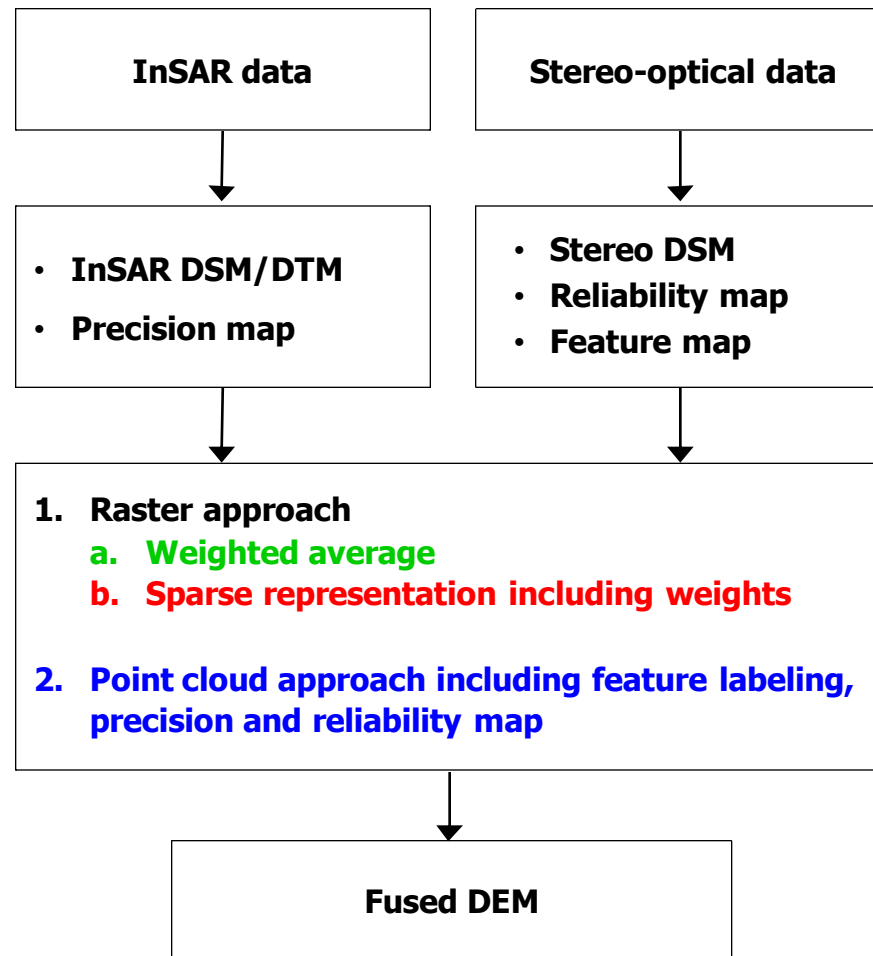
Weights

a weighting factor ranging from 0 to 1 is obtained by normalizing precision and reliability.

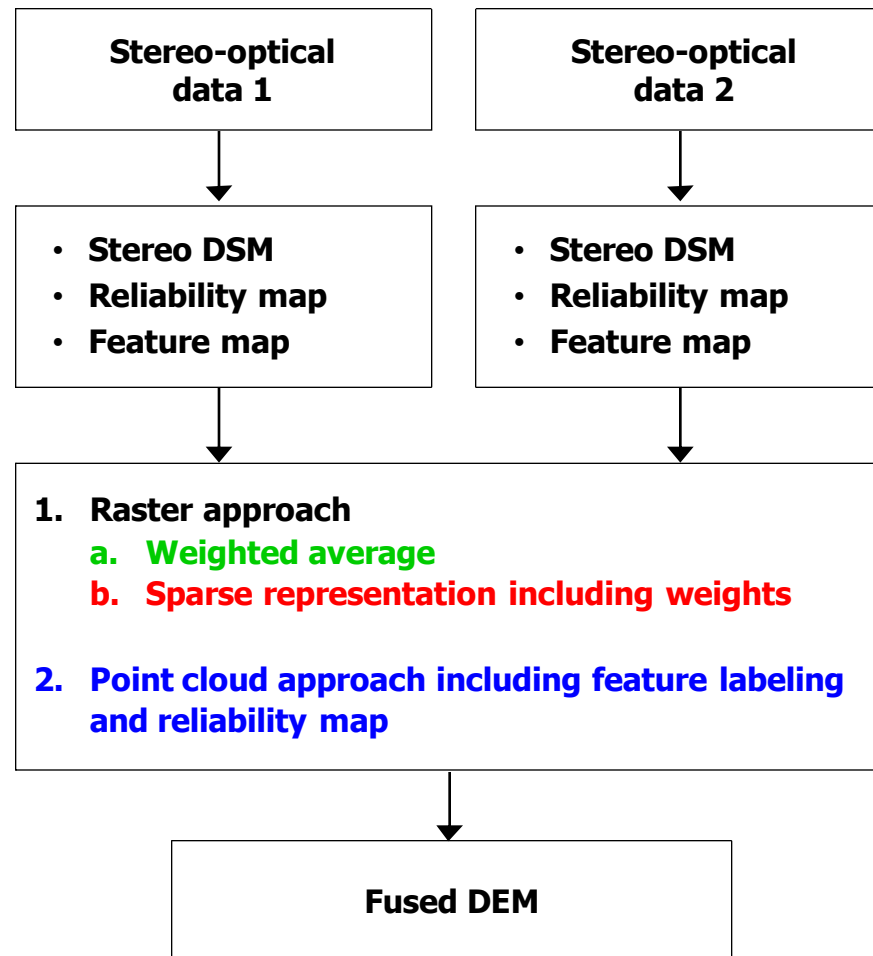
Feature map

features (edges in particular) detected and labeled in the point cloud.

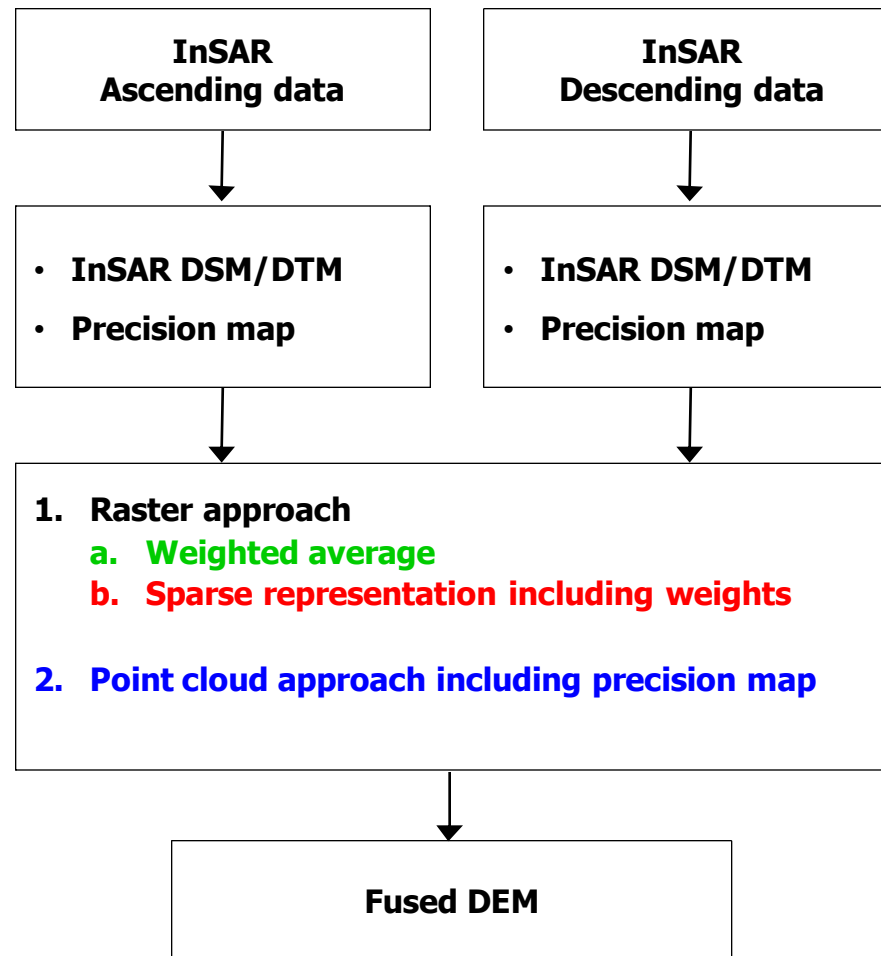
DEM fusion – Case 1: InSAR - stereo-optical



DEM fusion – Case 2: stereo-optical - stereo-optical



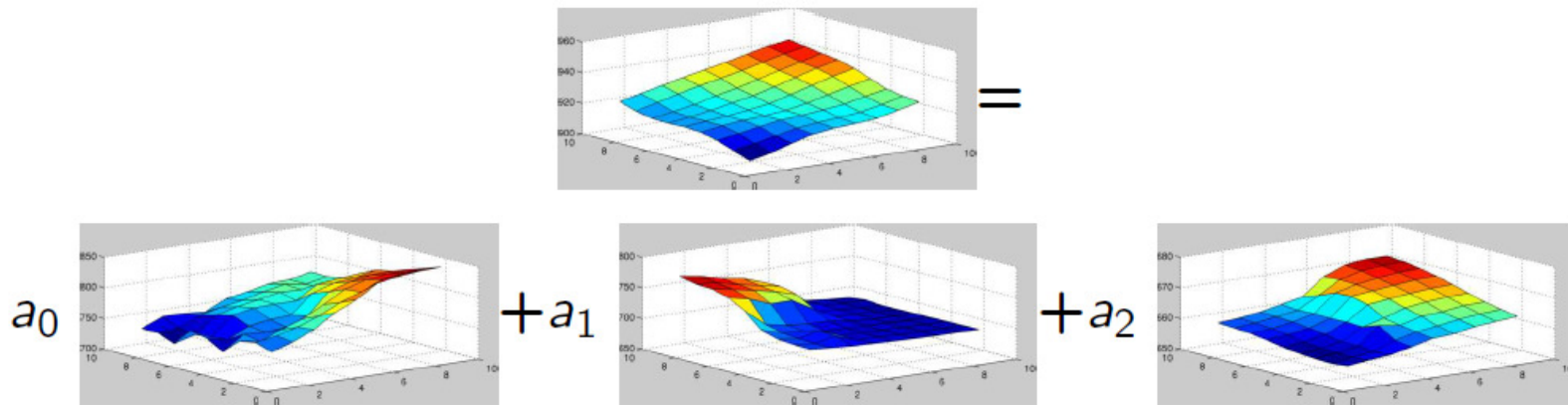
DEM fusion – Case 3: InSAR Ascending - InSAR Descending



DEM fusion – Sparse representation, approach 1/2

1. Definition of a dictionary (atoms) derived from available DEMs.
2. Computation of weights for the DEMs to be fused (a-priori knowledge).
3. Combination of atoms, weights, and the DEMs to be fused for the identification of the most appropriate atoms. This is performed solving a convex L1-norm optimization problem with Orthogonal Matching Pursuit .
4. Computation of the sparse non-zero coefficients vector based on the least square method.
5. Linear combination of the most representative atoms weighted by the coefficients.

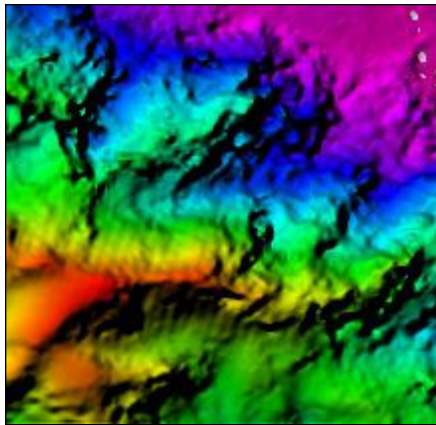
DEM fusion – Approach 2/2



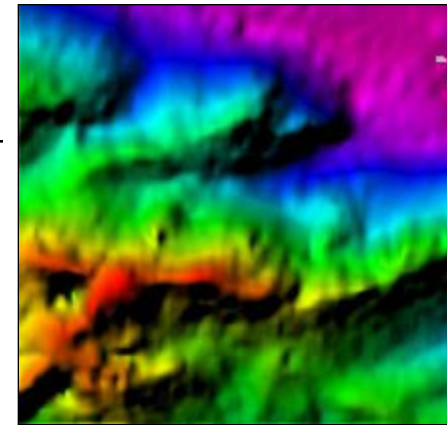
Where a is the sparse non-zero coefficient vector and each patch is an atom used to reconstruct the DEM.

DEM fusion – Sparse representation, example PALSAR-1 and SPOT-5

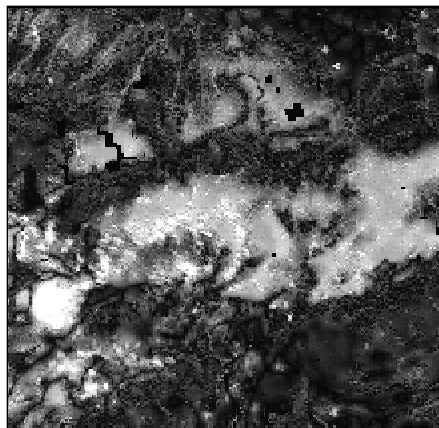
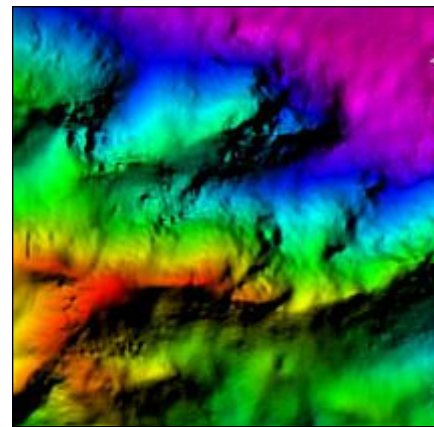
ALOS PALSAR-1 DEM



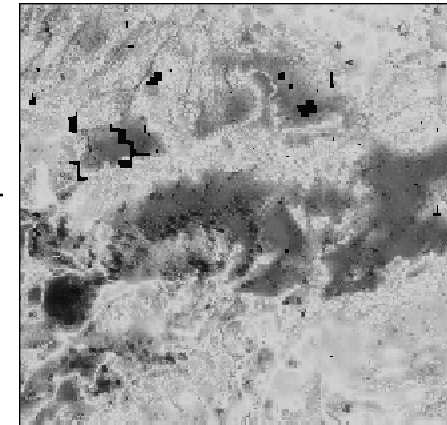
SPOT-5 DEM



Fused DEM



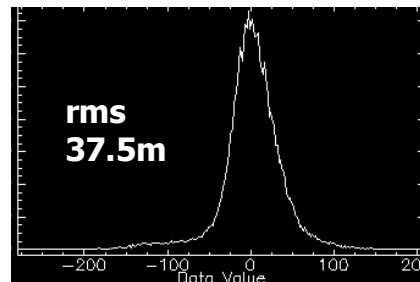
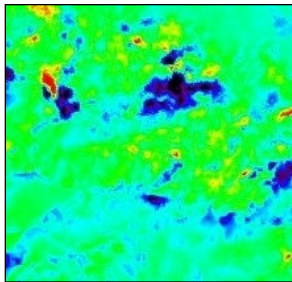
Weights map



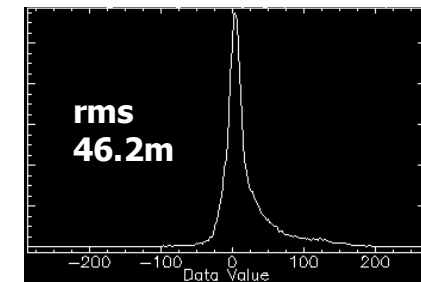
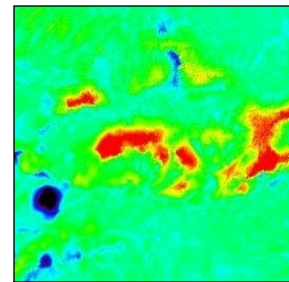
Weights map



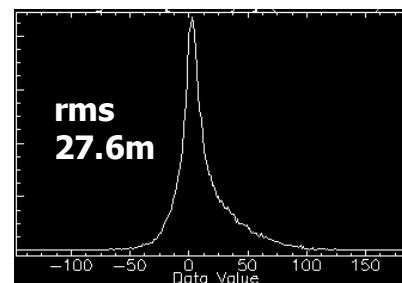
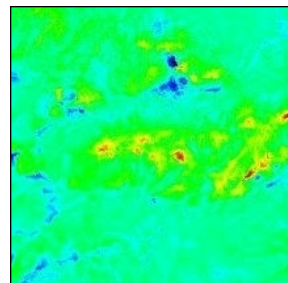
DEM fusion – Sparse representation, quantitative assessment



PALSAR-1 minus reference DSM



SPOT-5 minus reference DSM

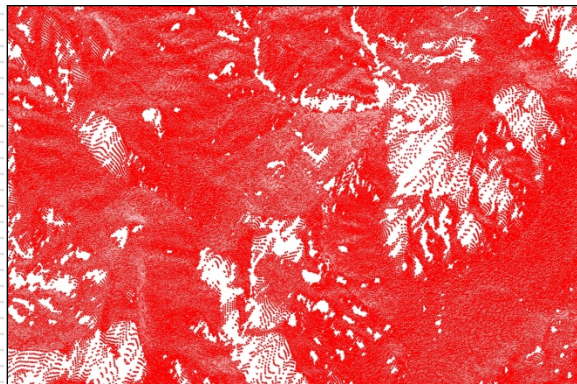
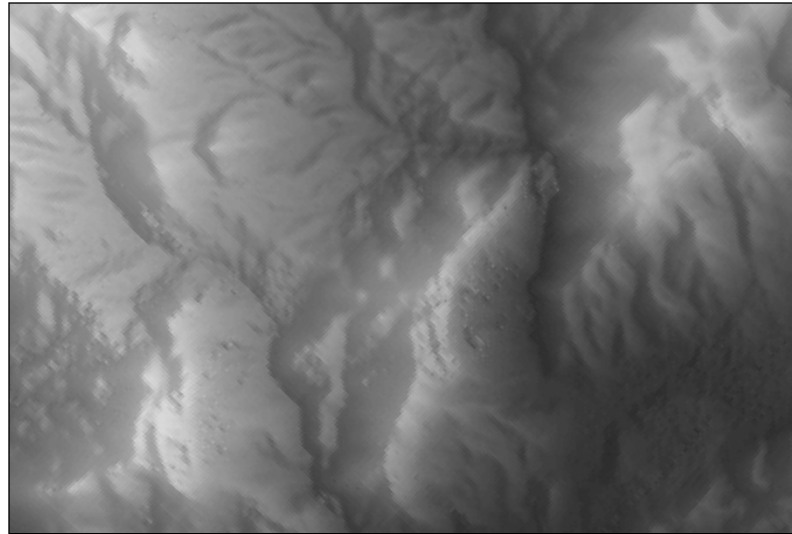


Fused DEM minus reference DSM

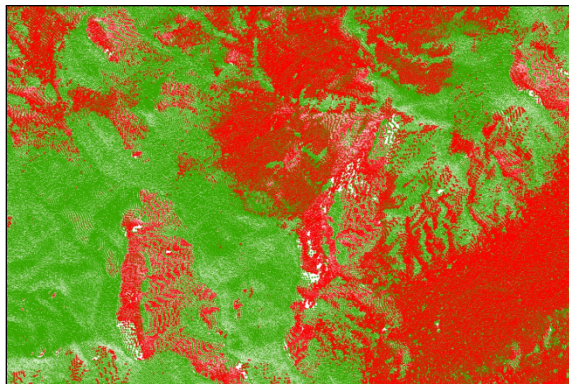
DEM fusion – Point cloud, approach

1. The two DEMs are generated as point cloud, hence avoiding error propagation caused by rasterization (interpolation).
2. The two point cloud DEMs are fused based on a (weighted) radial basis function approach by considering:
 - Feature labeling
 - Precision, for InSAR
 - Reliability, for optical

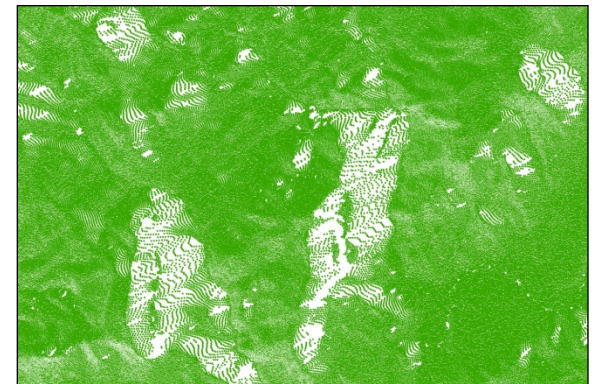
DEM fusion – Point cloud, example ERS-Tandem Asc & Desc



Ascending point cloud

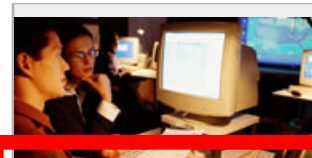


Ascending + Descending point cloud

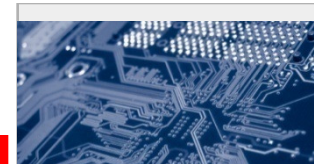


Descending point cloud

Link between SARscape-OPTICALscape ENVI and ArcGIS



AUTHOR
SHARE



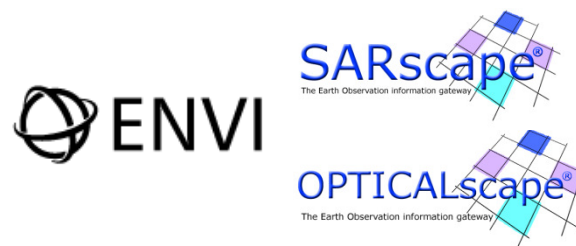
SERVE



USE

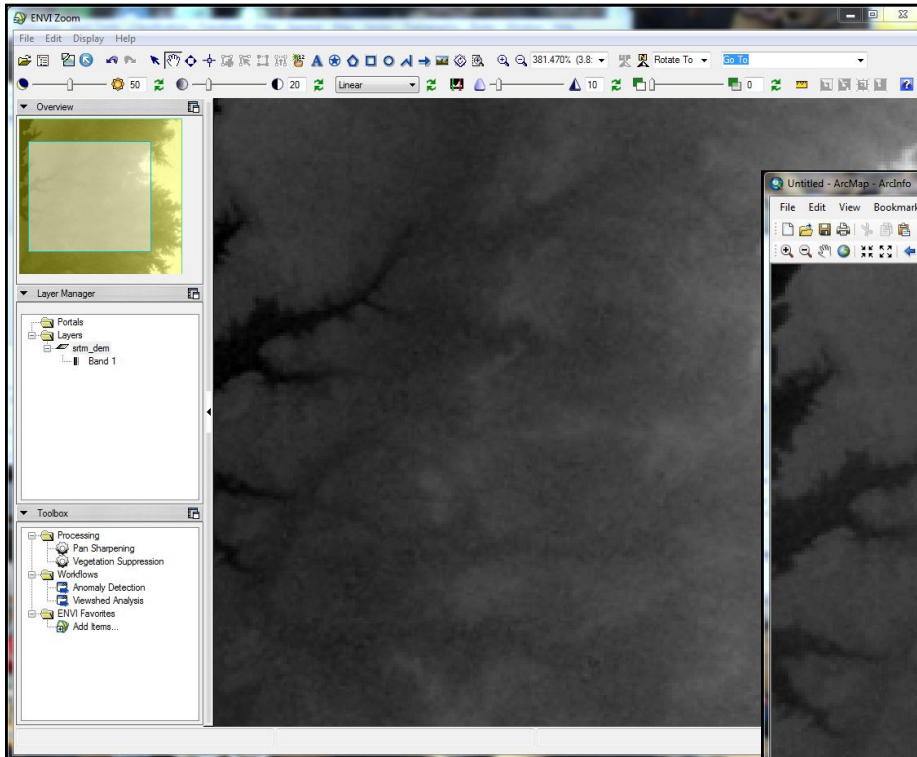
ACCESS

ANALYZE

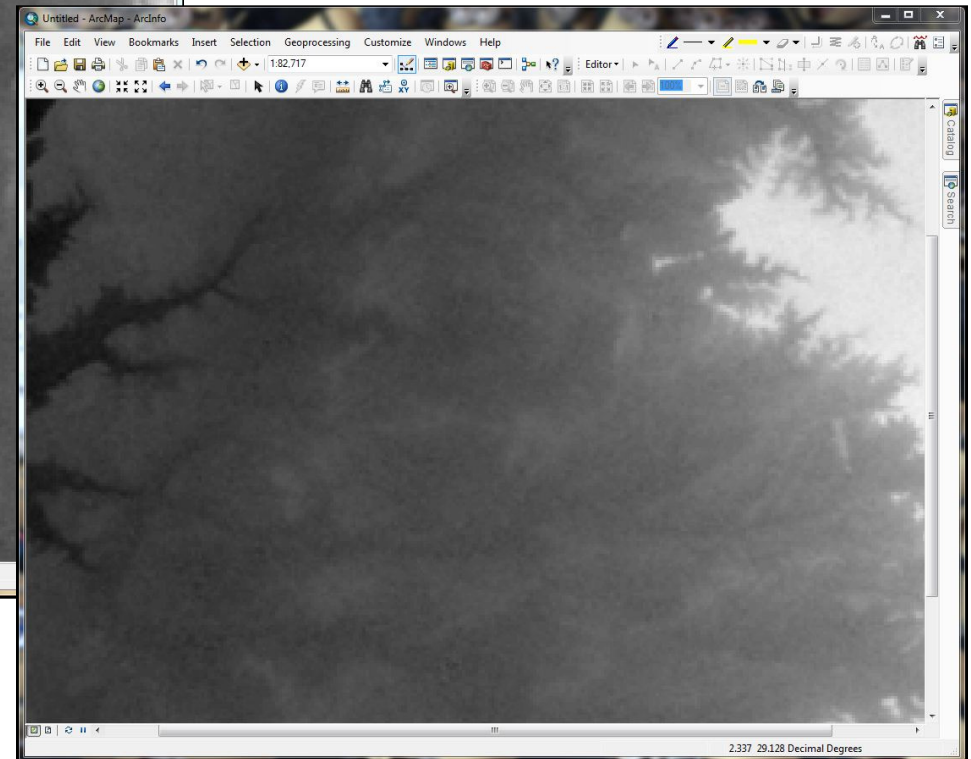


Link between ENVI and ArcGIS – Example

ENVI platform linked to ...



... the ArcGIS one



For further information visit our site
www.sarmap.ch

or contact the sarmap team at
sarscape@sarmap.ch