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OPTICALscape®

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:

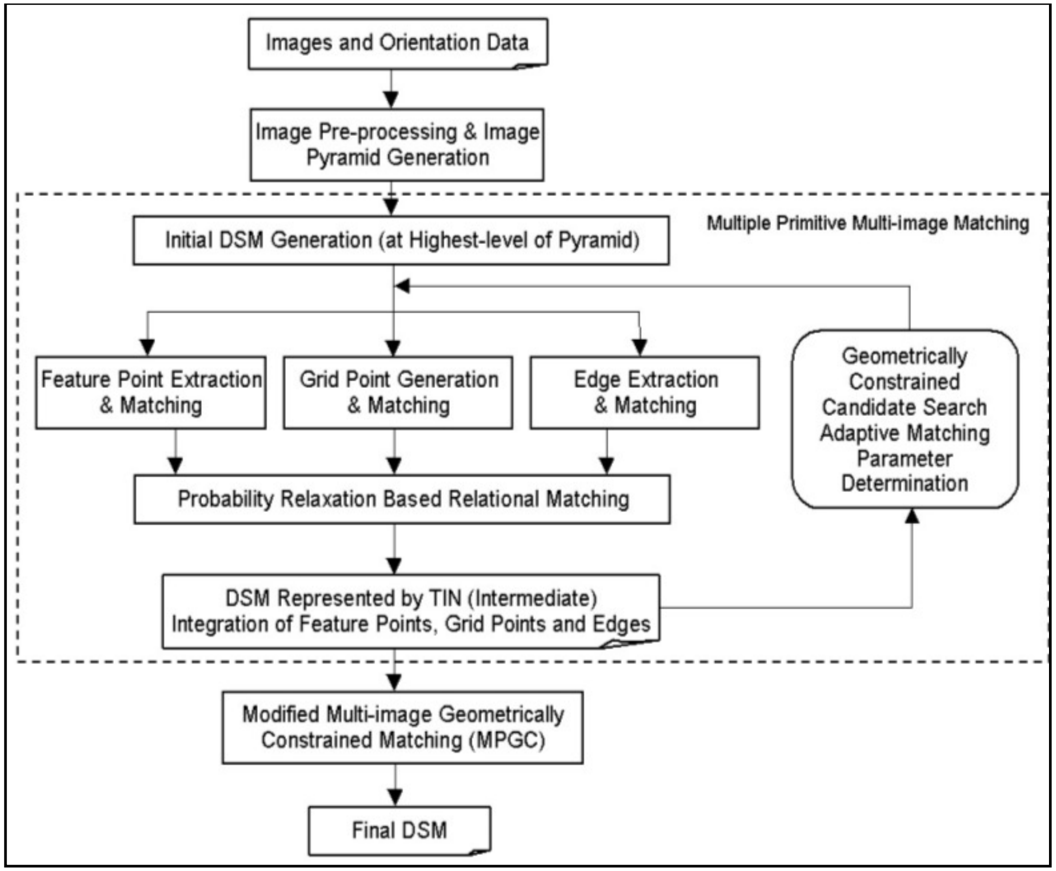
- DEM generation, which is based on an advanced matching algorithm. The approach uses a coarse-to-fine hierarchical solution with an effective combination of several image matching algorithms and automatic quality control. Moreover, the new characteristics provided by the latest imaging systems, i.e. 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

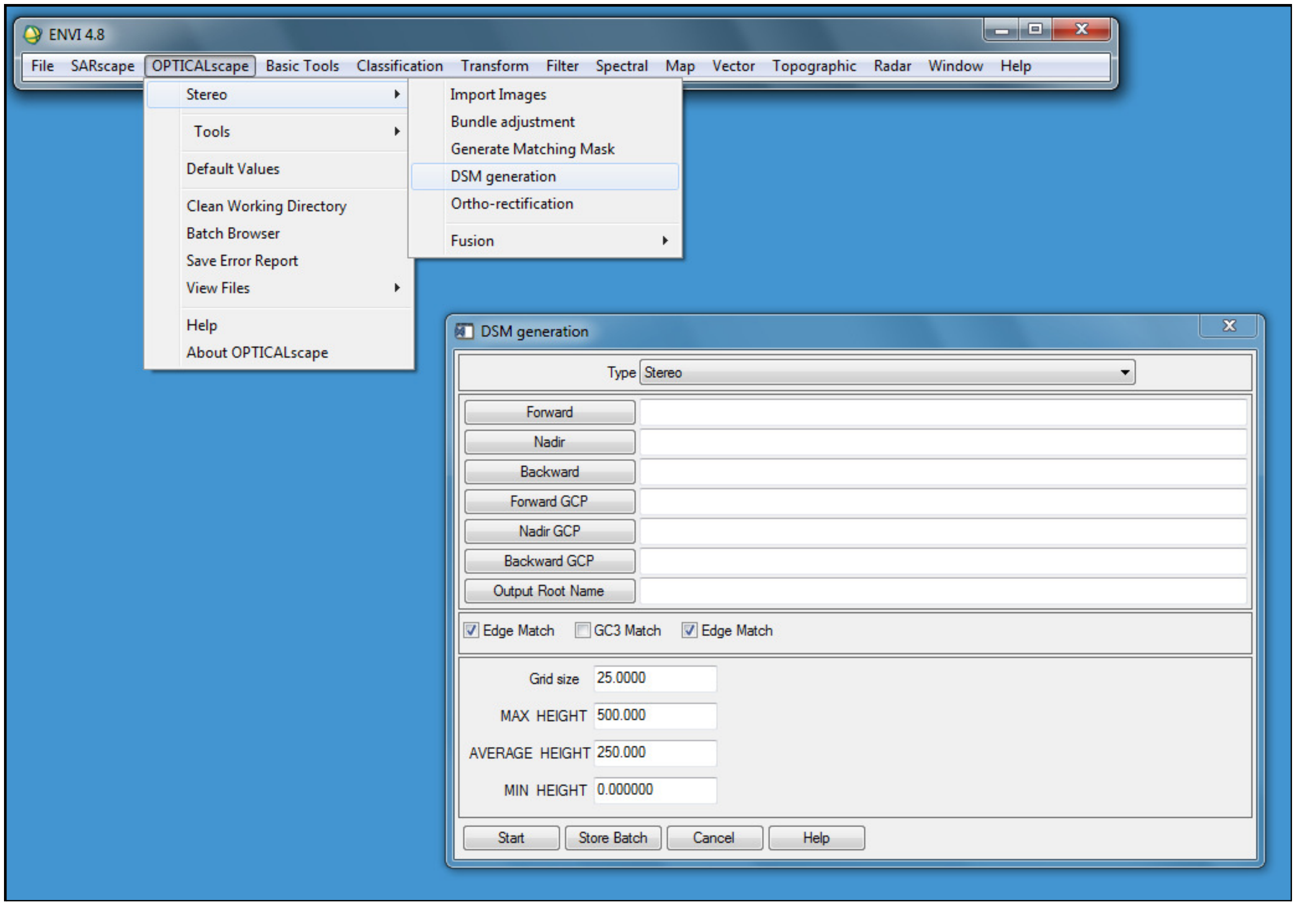
Spaceborne stereo-optical



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



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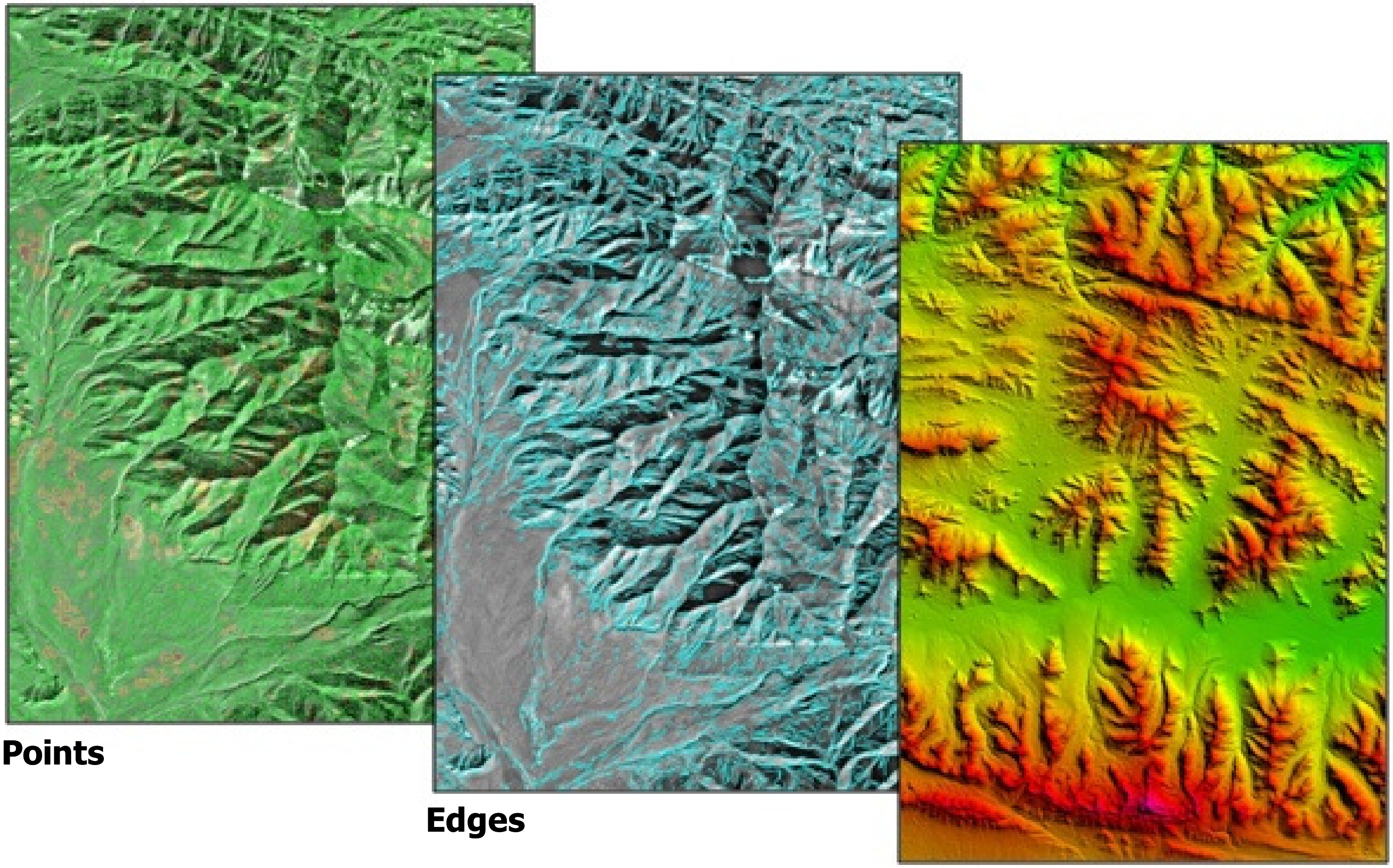
Spaceborne stereo-optical – SPOT-5 HRS

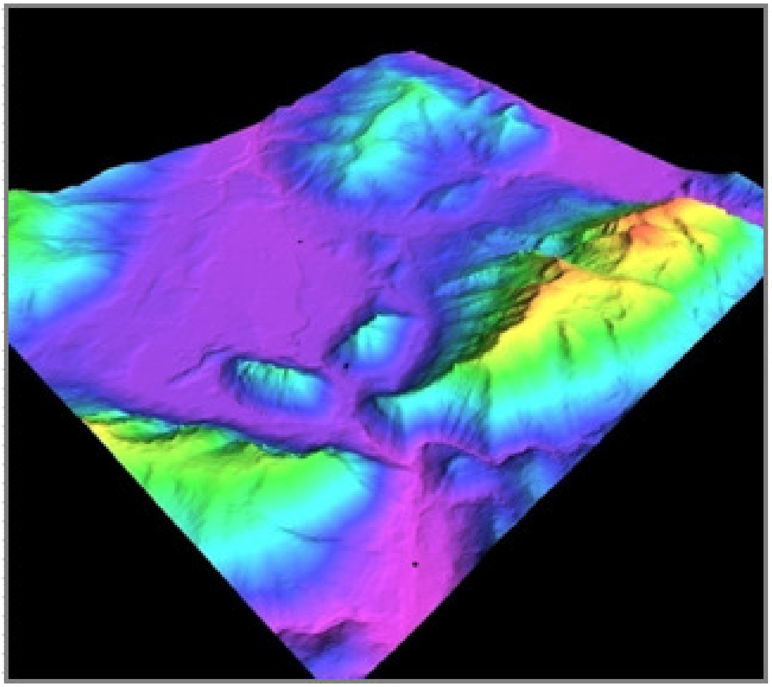


Points

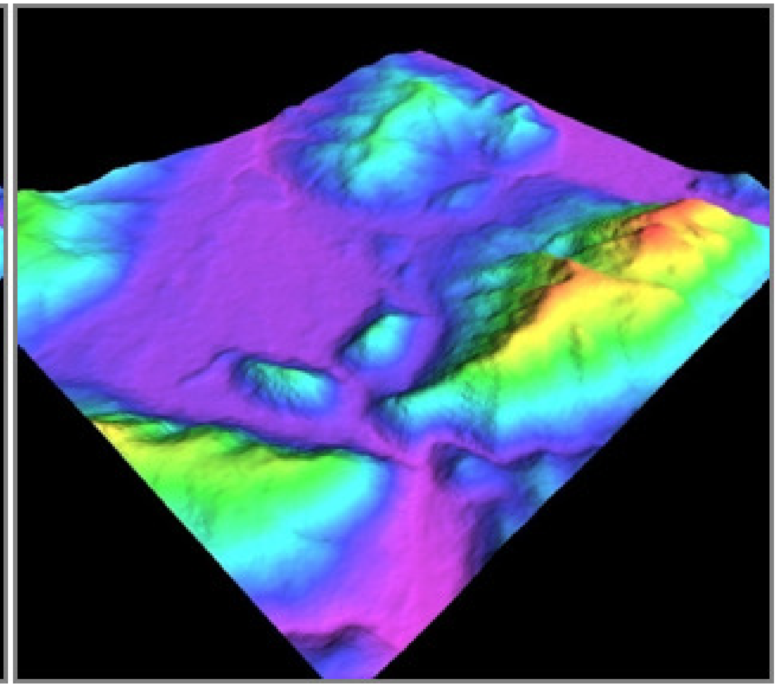
Edges

DEM

Spaceborne stereo-optical – SPOT-5 HRS

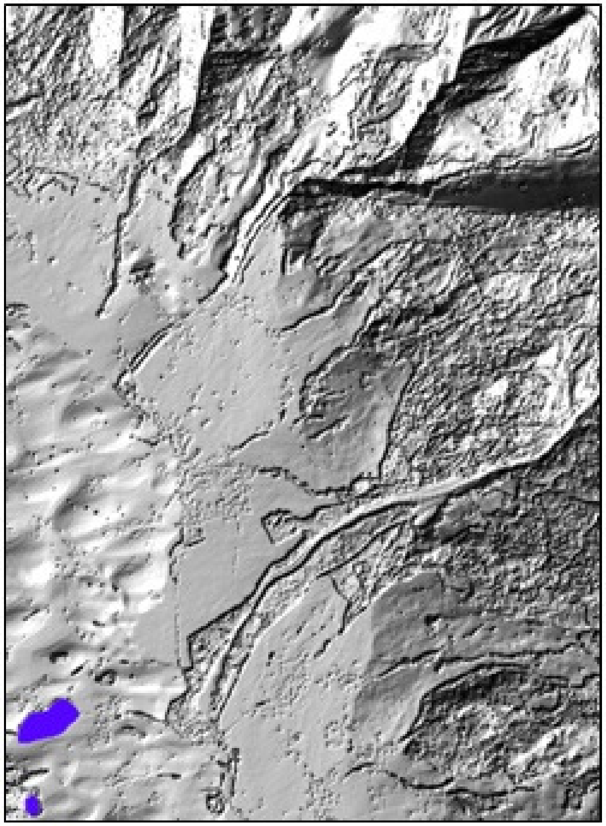


Reference DSM (5 m)

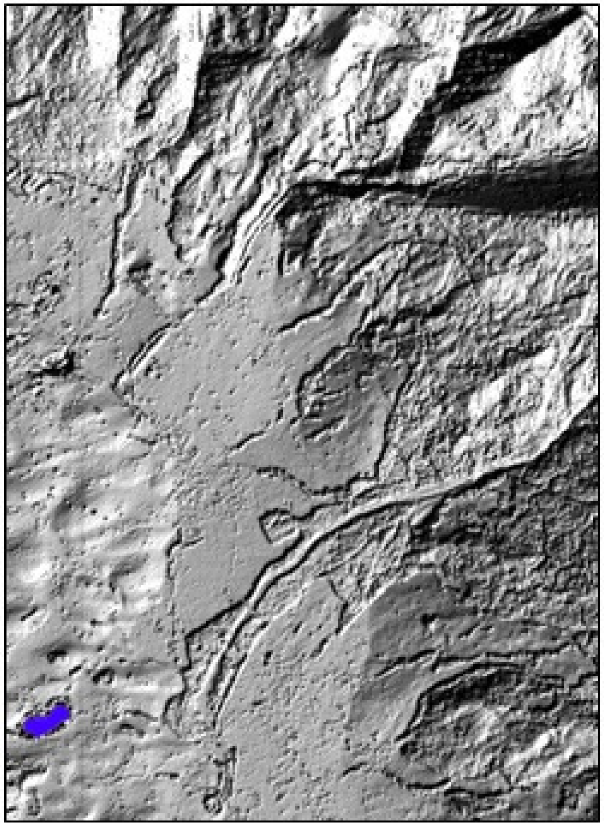


SPOT-5 DSM (25 m)

Spaceborne stereo-optical – IKONOS and comparison with LIDAR

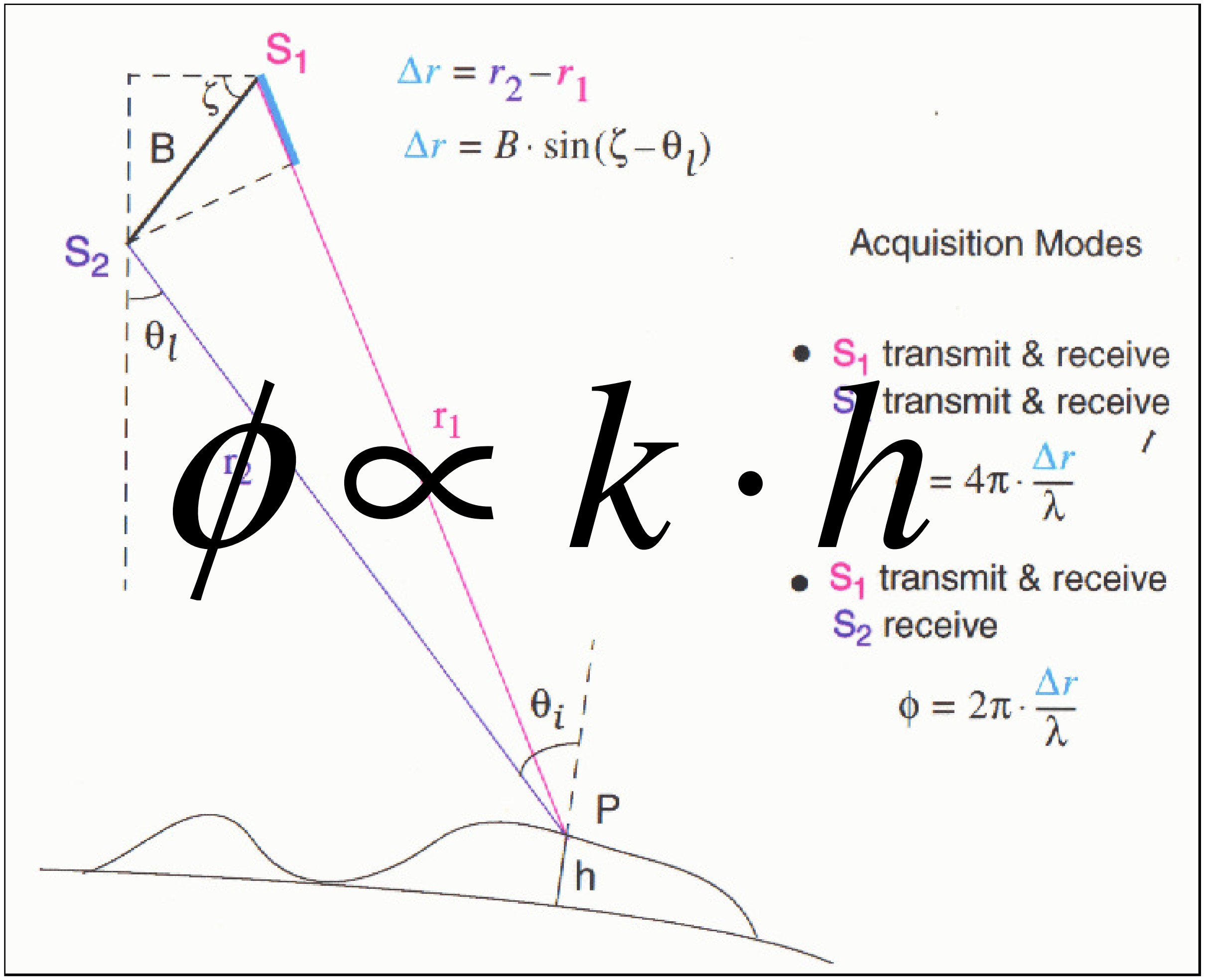


LIDAR DSM (2 m)

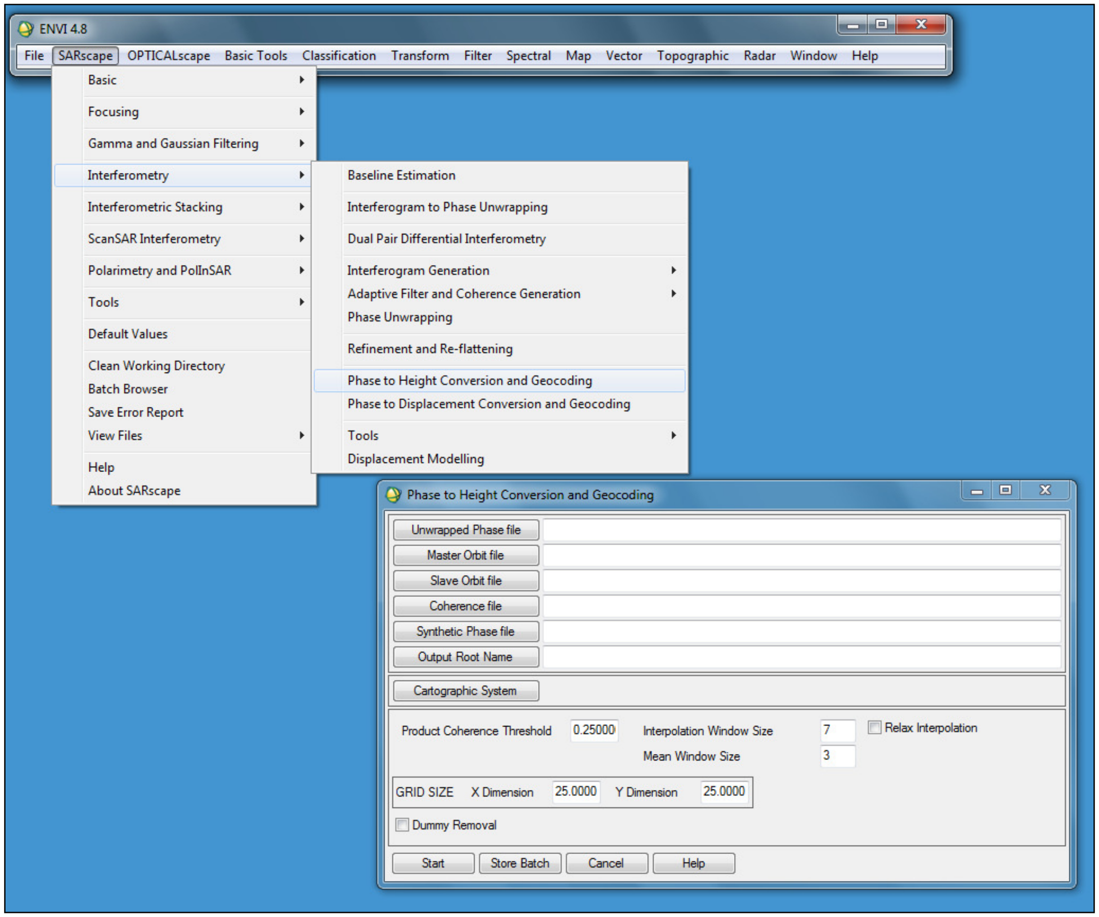


IKONOS DSM (5 m)

Synthetic Aperture Radar Interferometry (InSAR) – Principle



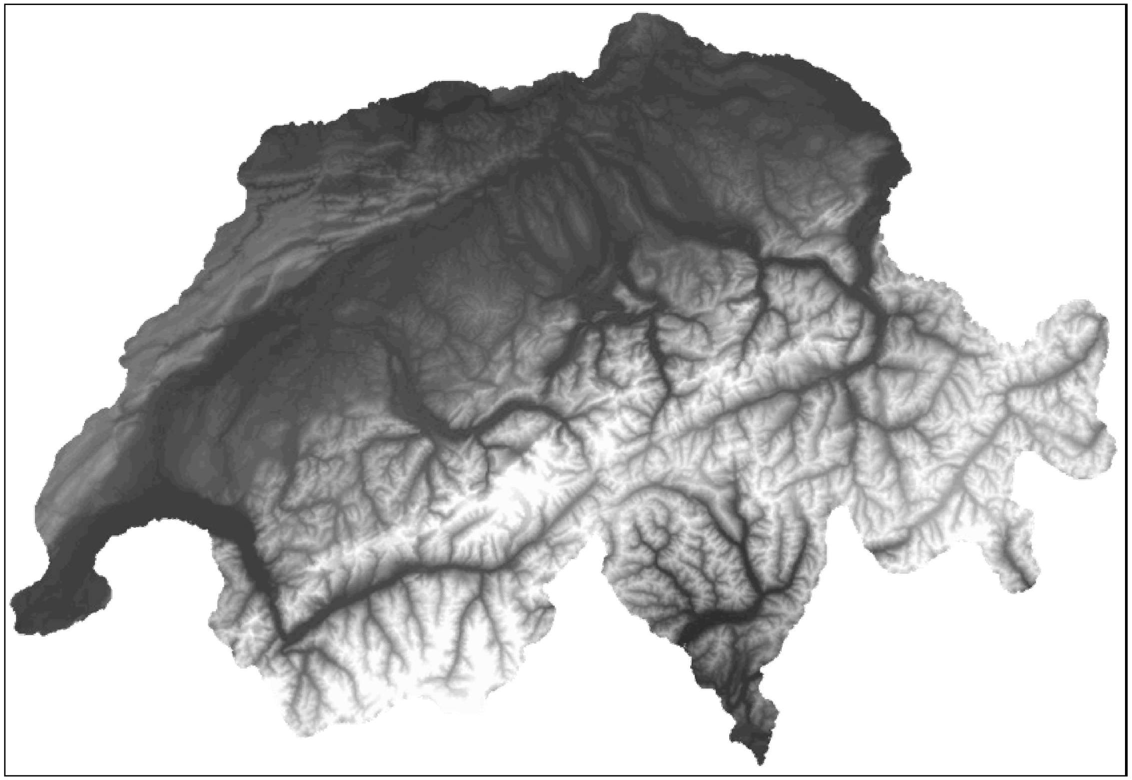
Interferometry Module – Interface



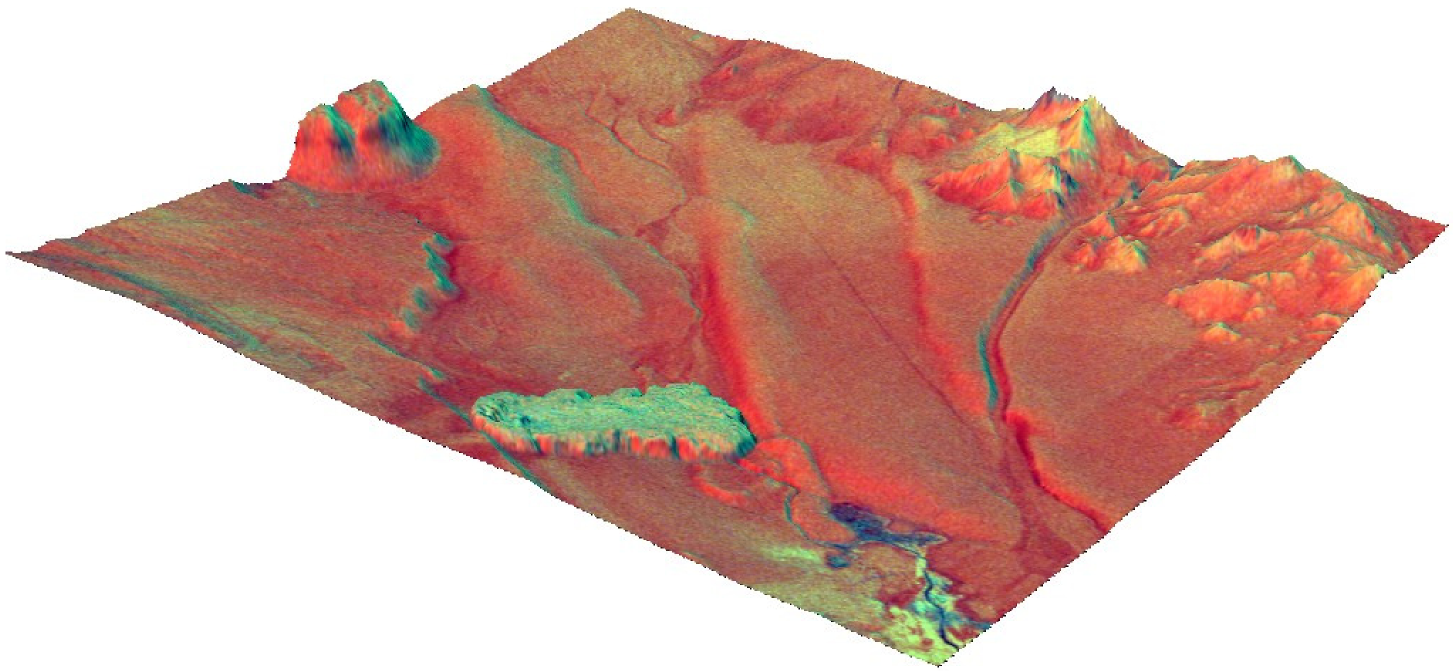
SAR Interferometry Module – Supported systems

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

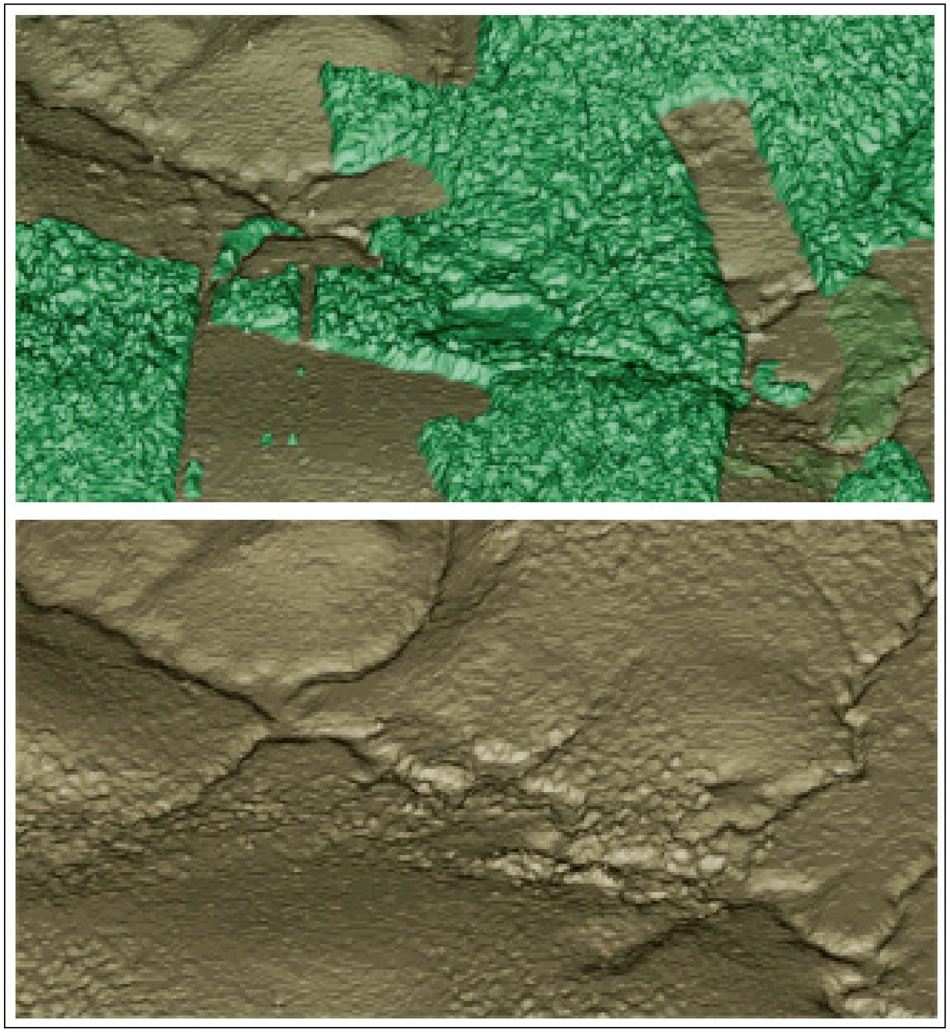


Spaceborne SAR Interferometry – TerraSAR-X-1, 3m



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

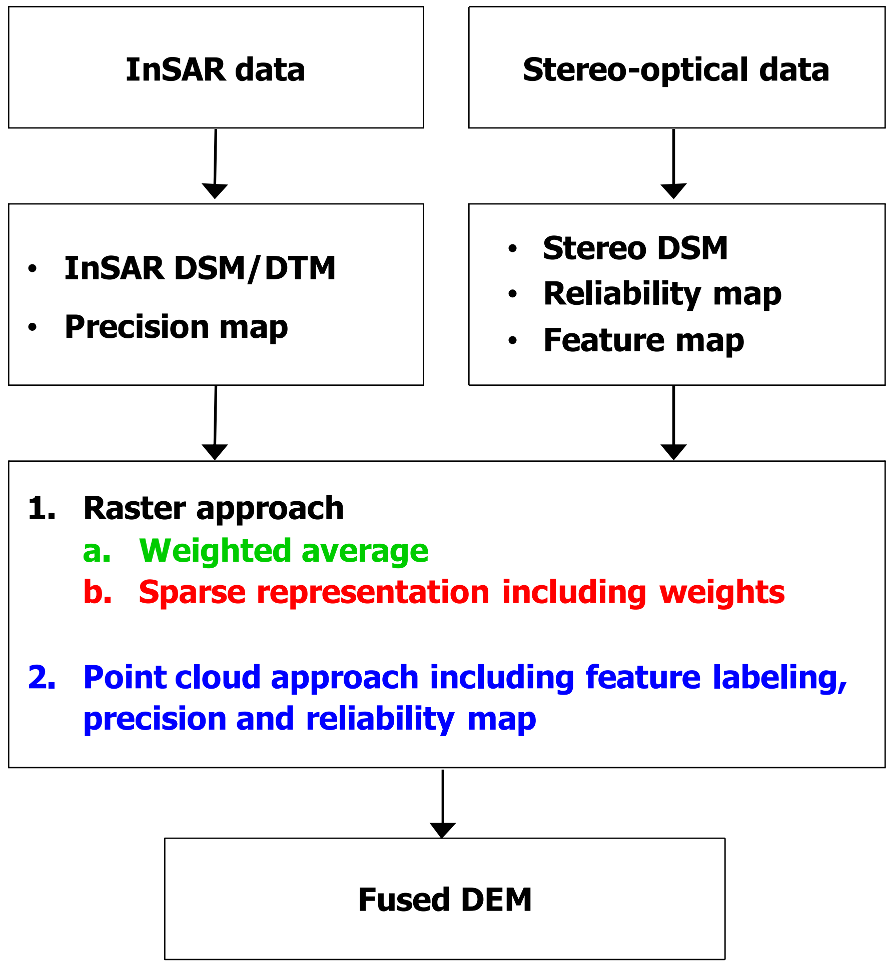
Precision estimated by exploiting
- baseline
- wavelength
- interferometric coherence
- local incidence angle (slope and aspect wrt the sensor)
- spatial ground resolution

Reliability estimated by exploiting
- cross-correlation
- slope and aspect

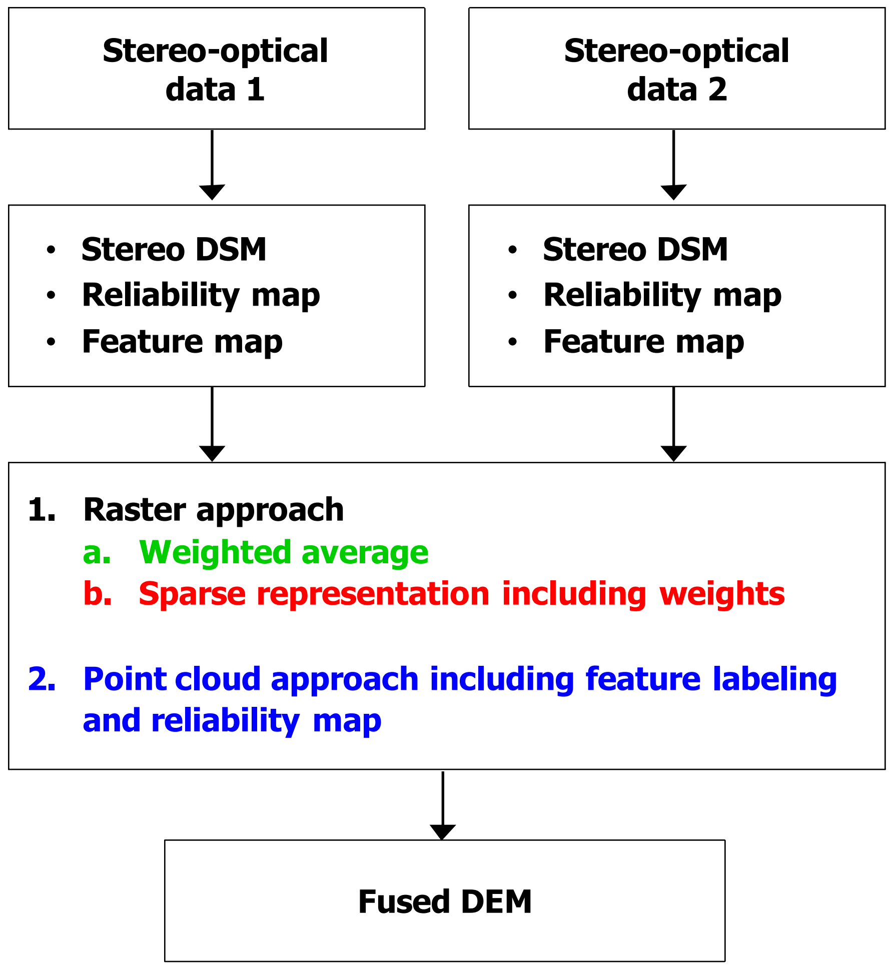
Weights a weighting factor ranging from 0 to 1 is otained by normalizing precision and reliability.

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

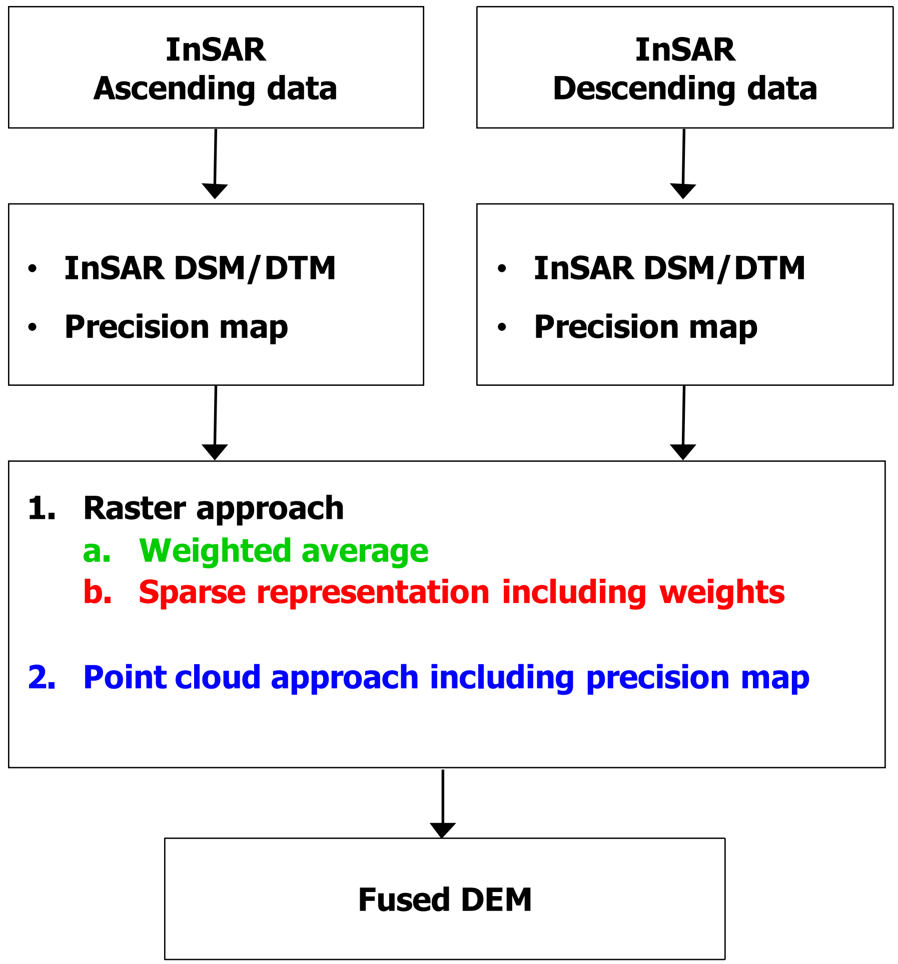
DEM fusion – Case 1: InSAR - stereo-optical



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



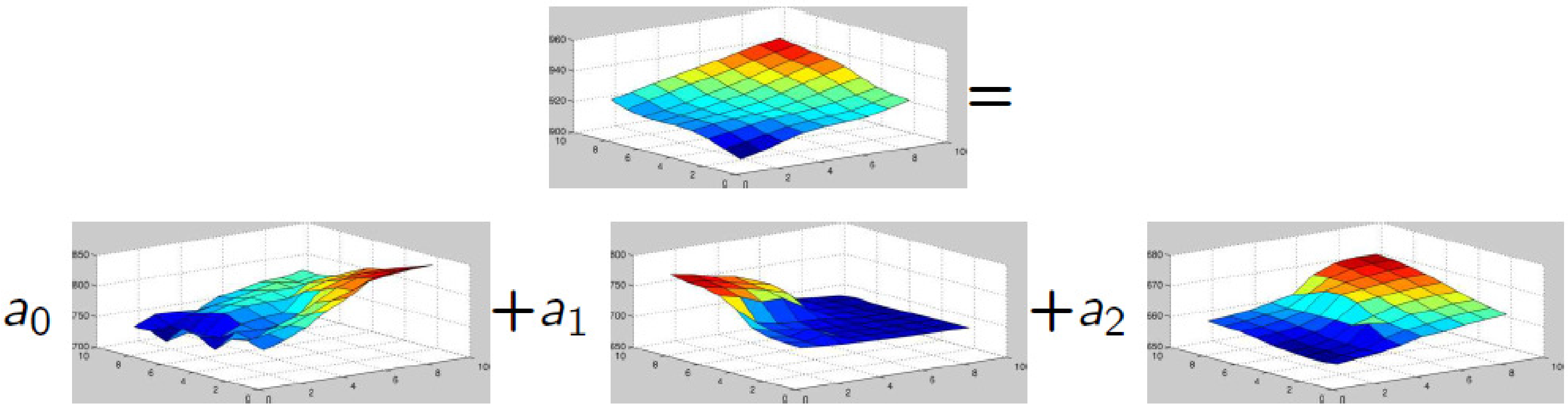
DEM fusion – Case 3: InSAR Ascending - InSAR Descending



DEM fusion – Sparse representation, approach 1/2

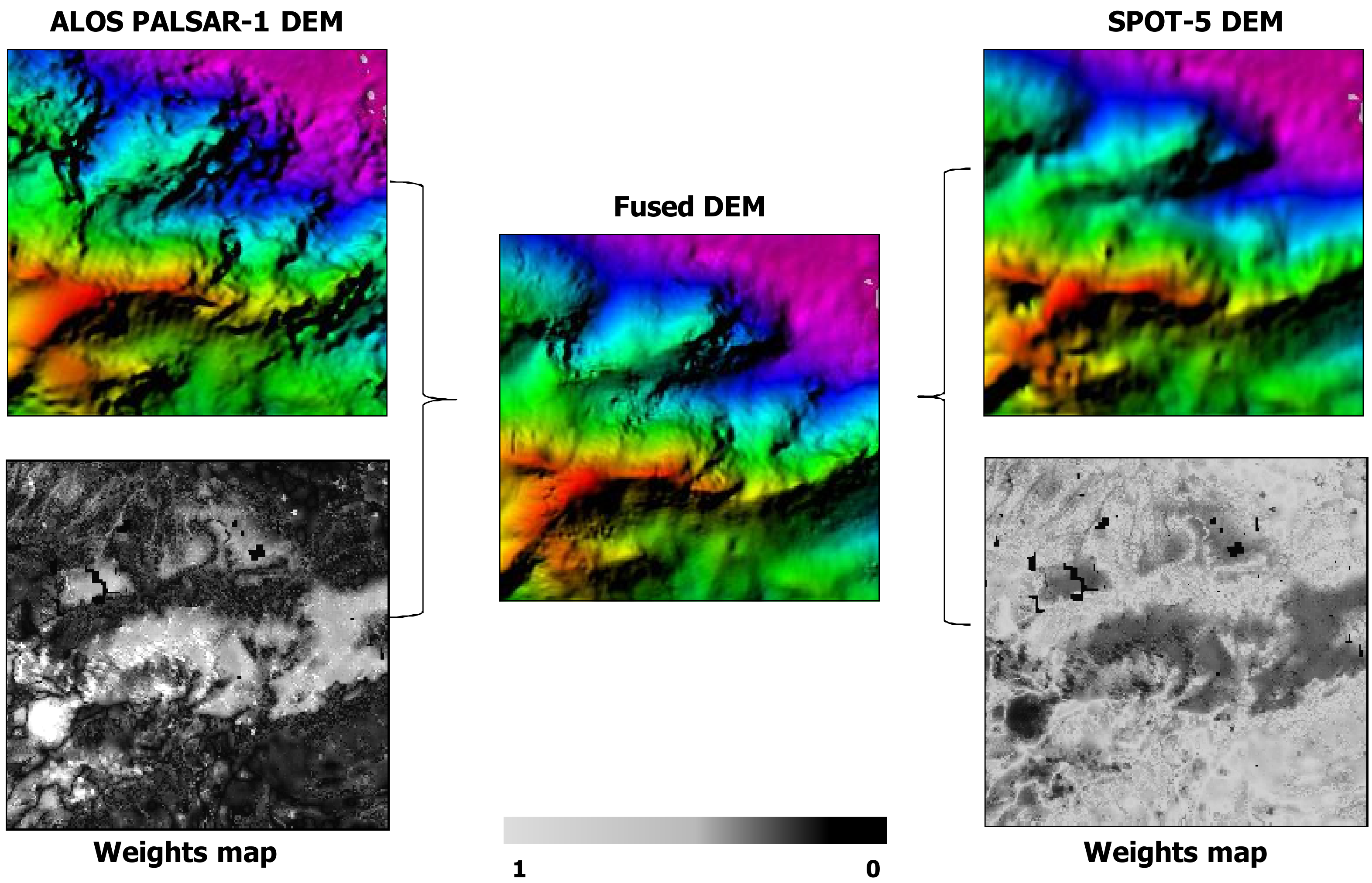
1. Definition of a dictionary (atoms) derived from available DEMs.
2. Computation of weights for the DEMs to be fused (a-priori knowledge).
3. Combinantion of atoms, weights, and the DEMs to be fused for the identification of the most appropriate atoms. This is performed solving a convex L1-norm optimization 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



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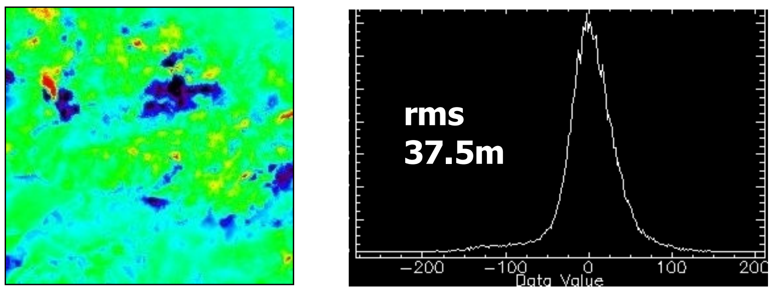
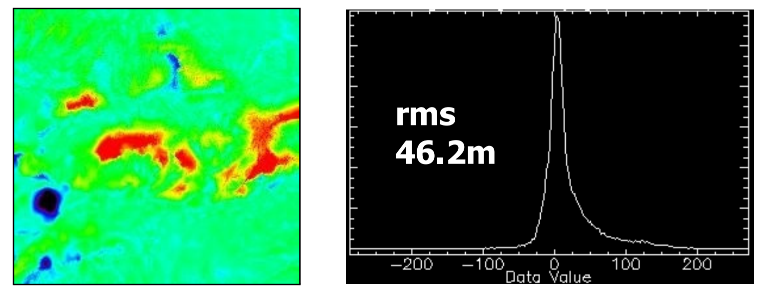
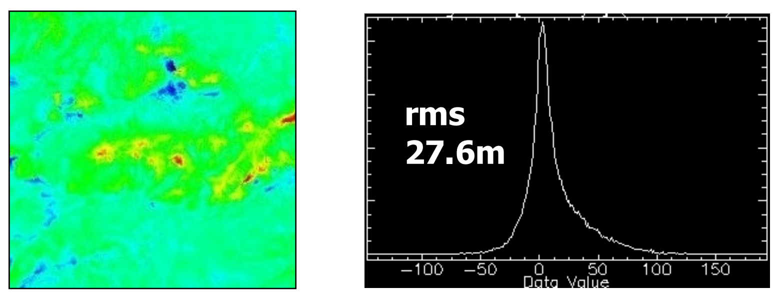
DEM fusion – Sparse representation, quantitative assessment



PALSAR-1 minus reference DSM



SPOT-5 minus reference DSM



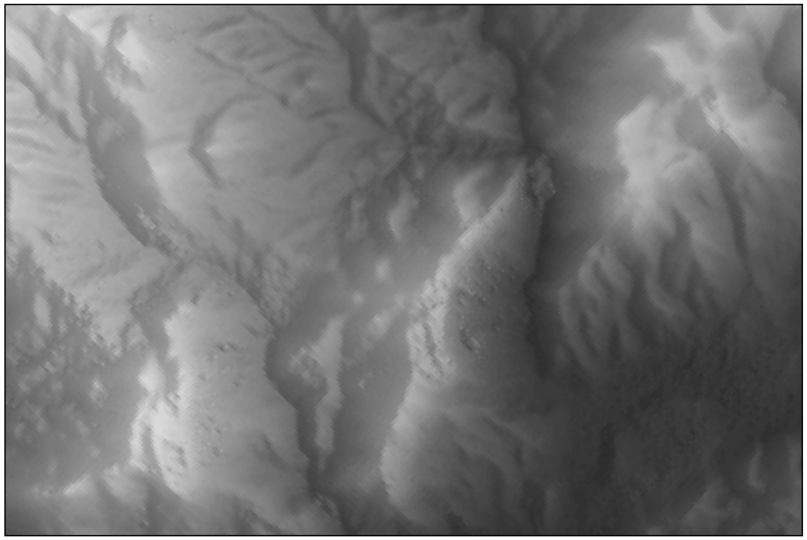
Fused DEM minus reference DSM

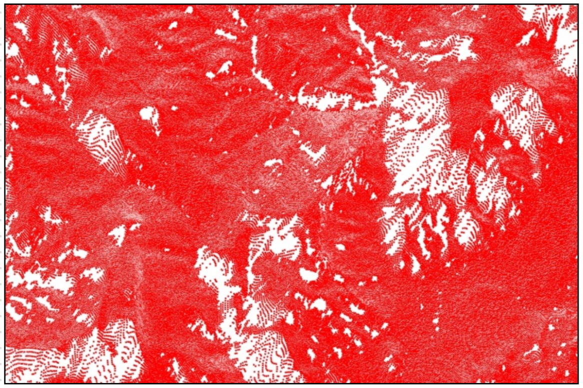
DEM fusion – Point cloud, approach

1. The two DEMs are generated as point cloud, hence avoiding error propagation caused by rasterization (interpolation).

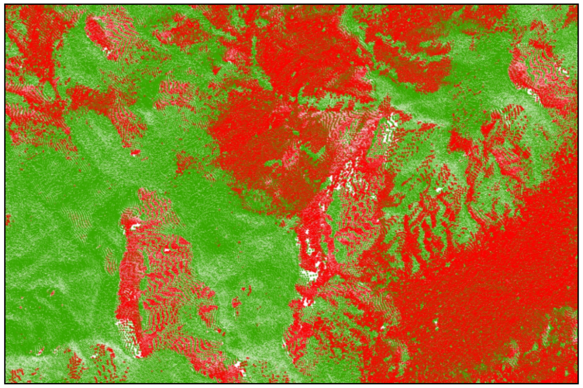
2. The two point cloud DEMs are fused based on a (weighted) radial basis function approach by considering:
   - Feature labeling
   - Precision, for InSAR
   - Reliability, for optical

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

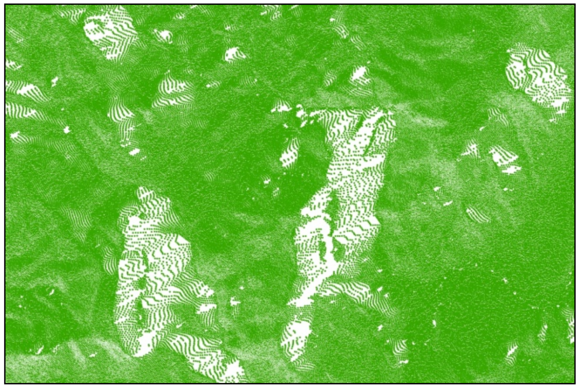




Ascending point cloud



Ascending + Descending point cloud

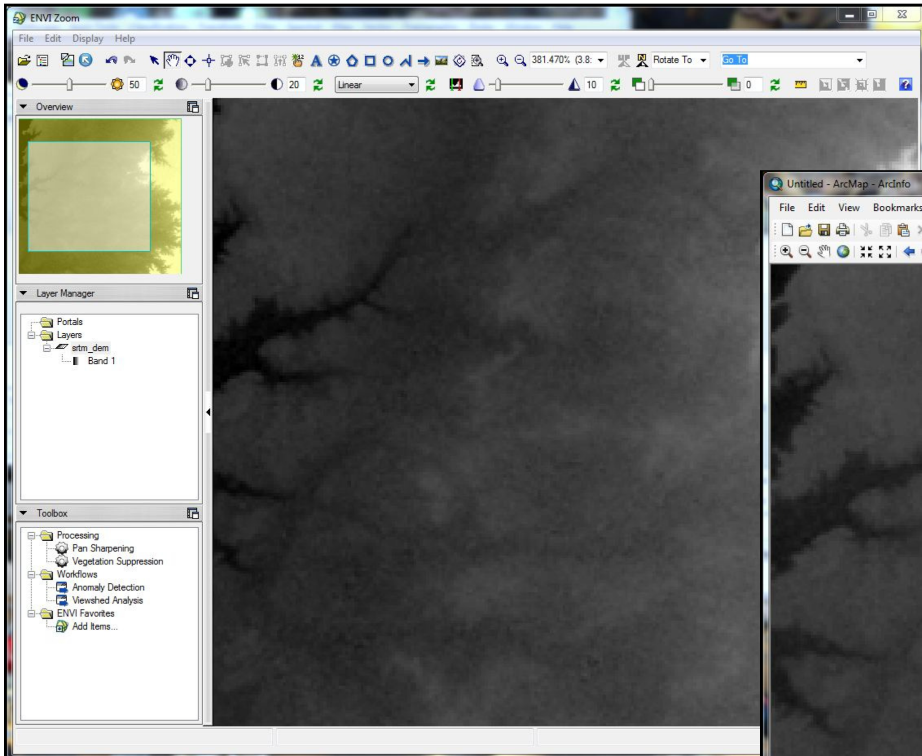


Descending point cloud

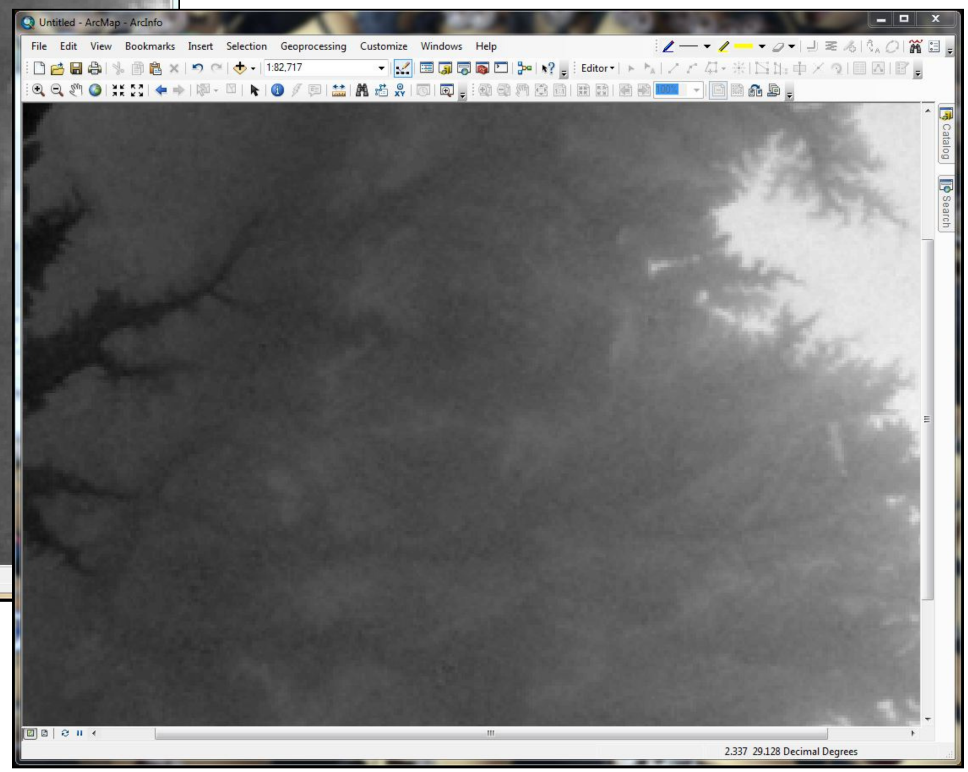
Link between SARscape-OPTICALscape ENVI and ArcGIS

Link between ENVI and ArcGIS – Example

ENVI platform linked to …



… the ArcGIS one



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