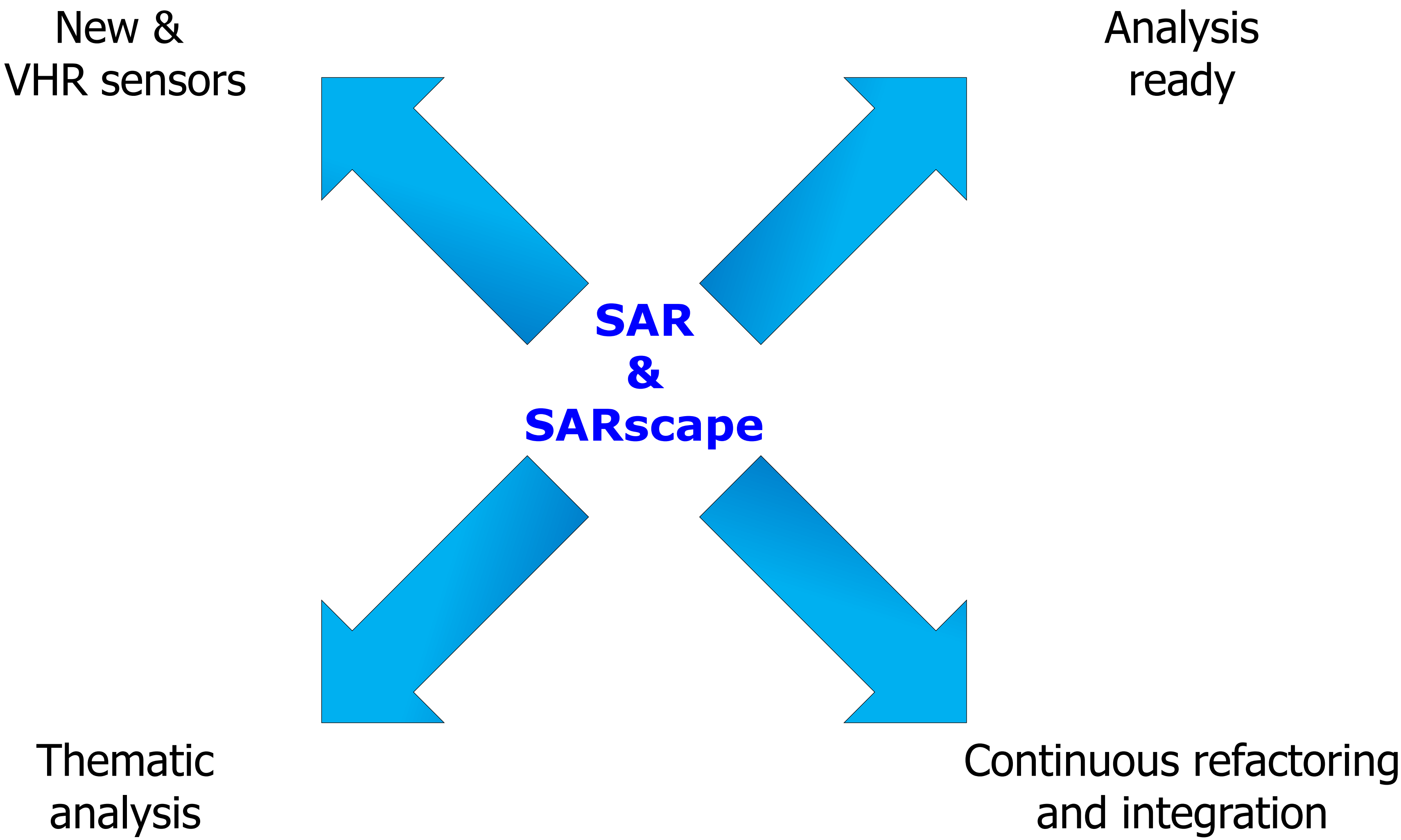
SAR and SARscape updates

Dr Paolo Pasquali

Co-founder, President and Technical Director



From SARscape 6.2 on

Analysis Ready Data

Several activities on-going.
A major one: CEOS Analysis Ready Data for Land (CARD4L).

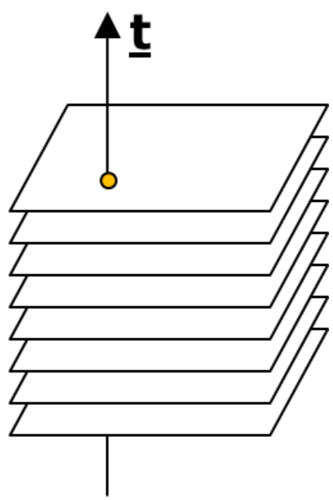
"CEOS Analysis Ready Data (CEOS-ARD) are satellite data that have been processed to a minimum set of requirements and organized into a form that allows immediate analysis with a minimum of additional user effort and interoperability both through time and with other datasets."

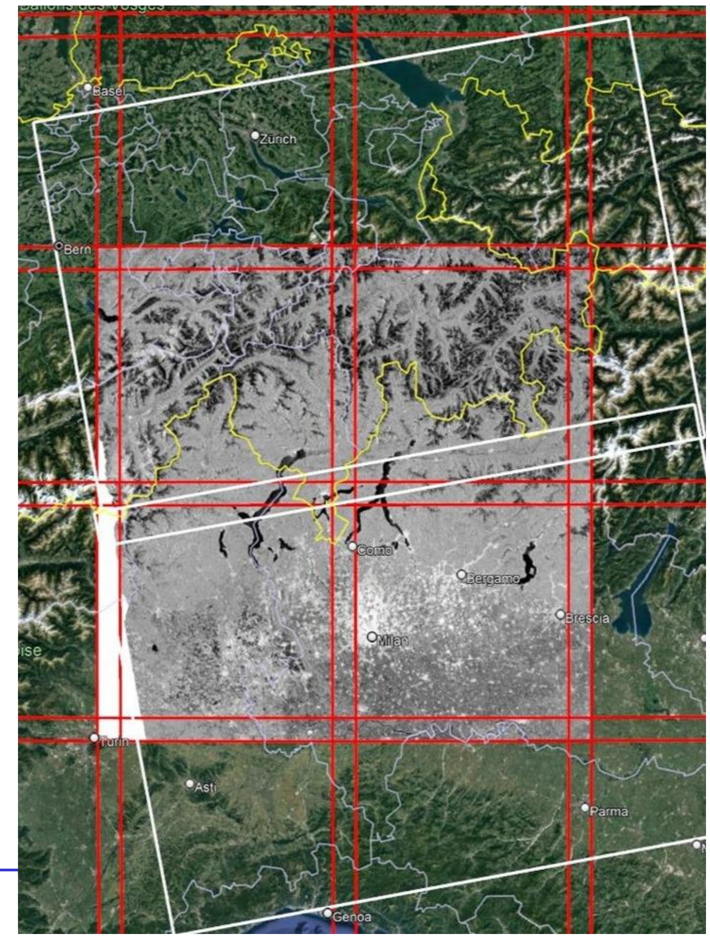
Involved institutions: ASF, CONAE, CSIRO, DLR, ESA, EU JRC, Geoscience Australia, ISRO, Jaxa, JPL, NASA, NRC, U. Stanford, UNIZH, USGS,....

Analysis Ready Data

One of the defined products: SAR NRB (Normalised Radar Backscatter)

- Orthorectified / geocoded / terain corrected
- Gamma-Nought (γ_T^0) backscatter
- Regular grid (tiles)
- Coregistered over time





Analysis Ready Data

Another defined product: SAR GSLC (Geocoded Single-Look Complex)

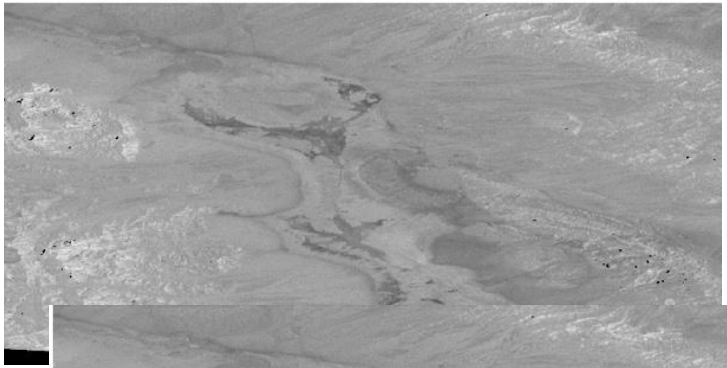
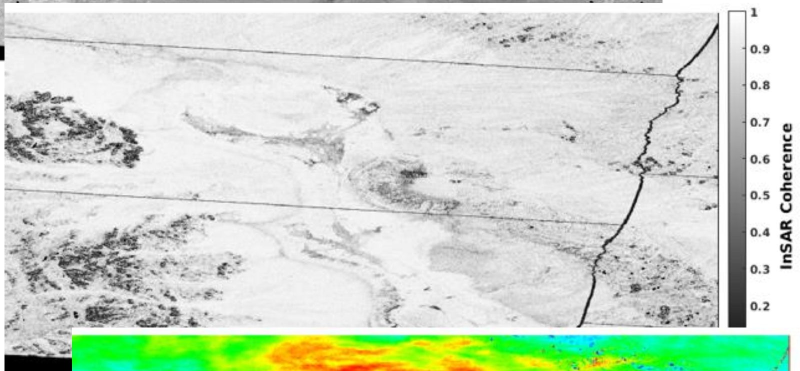


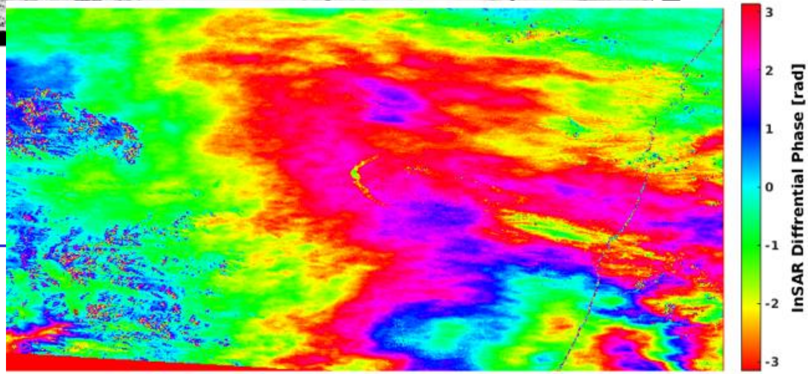
Image 1

Image 2

Interferograms obtainable as direct pixel-by-pixel product



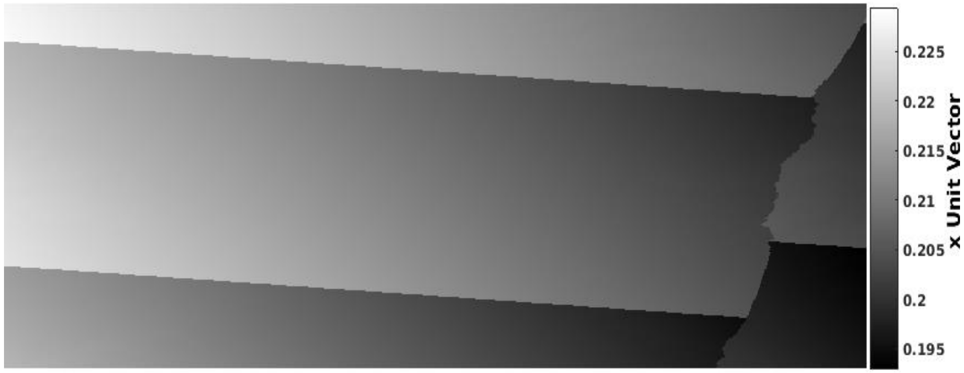
Coherence



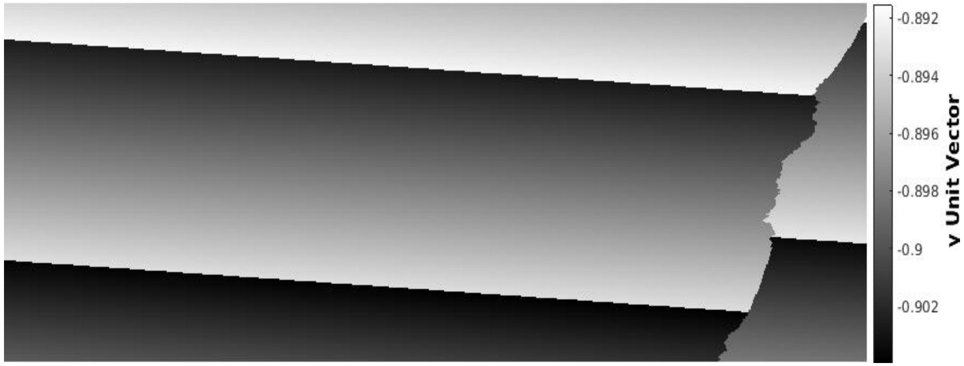
Flattened interferogram

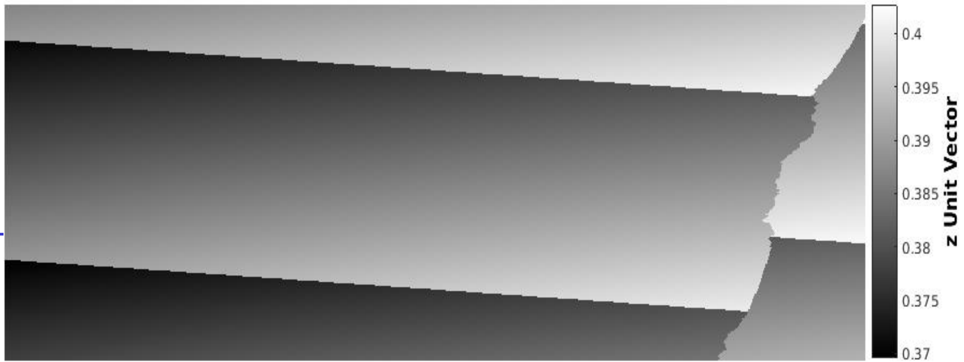
Analysis Ready Data

Another defined product: SAR GSLC (Geocoded Single-Look Complex)



Additional layers provided to reconstruct the pixel-by-pixel geometry)





Analysis Ready Data

- Some of the pre-processing steps already carried out.
- Pixel-by-pixel comparison easier.
- All needs of accurate information extraction methods remain equal.
- Steps difficult to revert or impacting on processing:
  - After geocoding, statistic of speckle depending on slope (impact on accuracy of speckle filtering).
  - Coregistration…
  - Spectral-shift filtering very difficult to apply on geocoded data.
  - Geocoding: what if better accuracy DEM available?
  - Geocoding: what if better DEM extracted from phase?
  - …

-> Our view: already easy steps made "easier", complicated steps made more complex.

SARscape -> unified aproach to stacks

- Multi-temporal stack as "unit"
  - ➔ Same auxiliary file, connection graph,… for Amplitude (e.g Intensity Time Series) as for Phase (InSAR, xPS, xSBAS, Multi-Temporal coherence…).
  - ➔ Unified xPS and SBAS pre-processing (SLC coregistration)
- Choice between slant (preferred) or geocoded geometry as major reference.
  - ➔ Support of ARD data
    - ➔ Format
    - ➔ Geometry
    - ➔ Adapt steps / reconstruct information / optimize
  - ➔ Support of time-domain processed data (e.g., a few VHR airborne SAR)

New & VHR sensors

- PALSAR-3

- Synspective Strix
- iQPS QPS-SAR

- Capella Space
- Umbra

- ICEYE

- LuTan-1
- HJ-2E - Huan Jing 2E
- HT-1 - Hongtu-1
- Spacety Hisea-1
- SV-2
- Fucheng 1

- NISAR….

Continuously

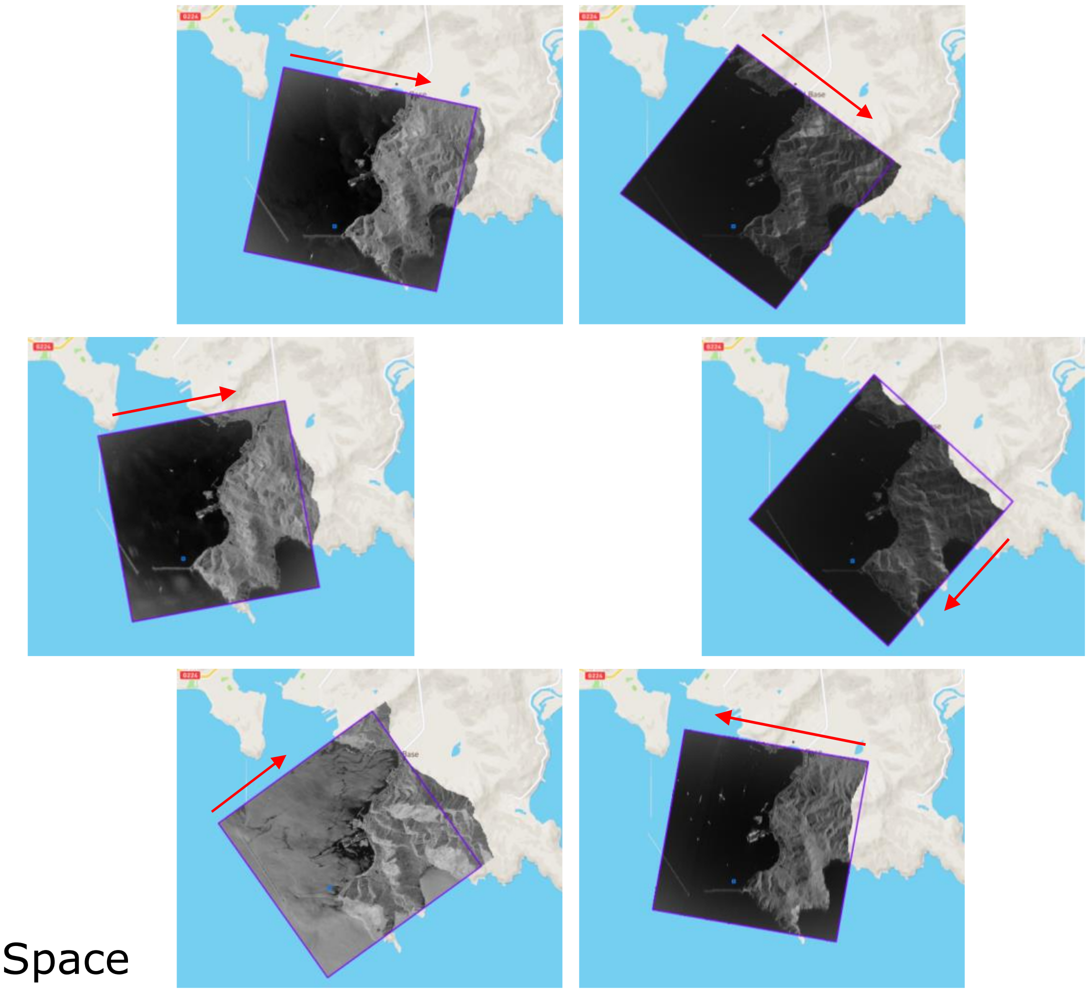
New & VHR sensors

Often:
- Different orbital planes
- Large orbital tubes
- Limited control of squint
- Little focus on repeated geometry

Very-high resolution:
- Long observation time

Different bands and modes

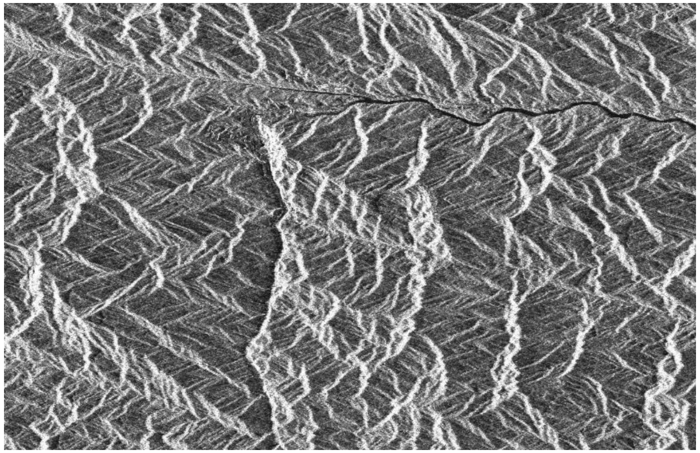
Often:
- Self-tasking API

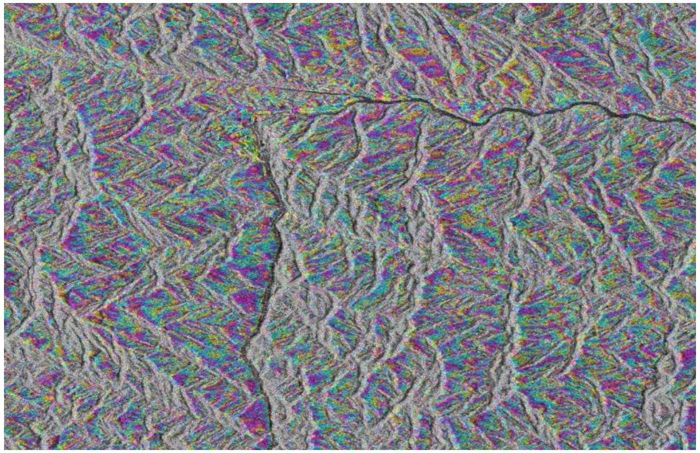


Capella Space

New & VHR sensors: different modes

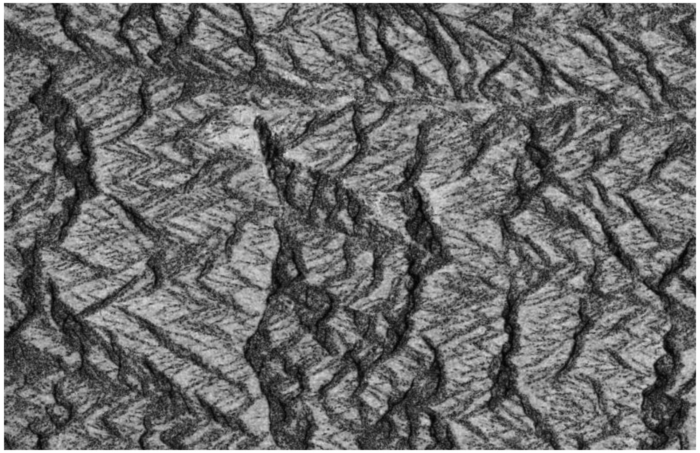
Reference

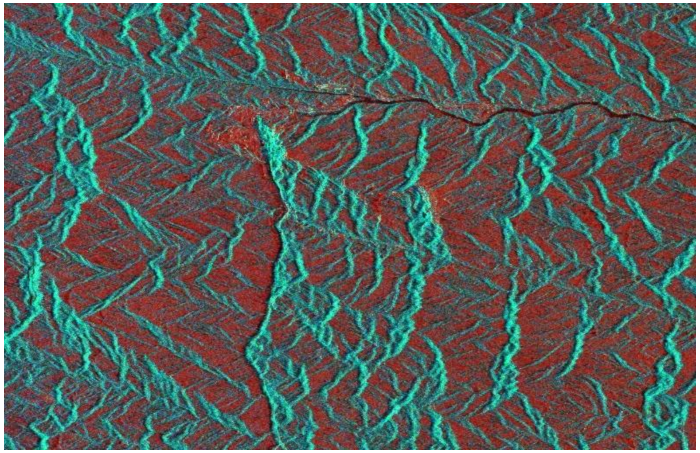




Interferogram

Coherence

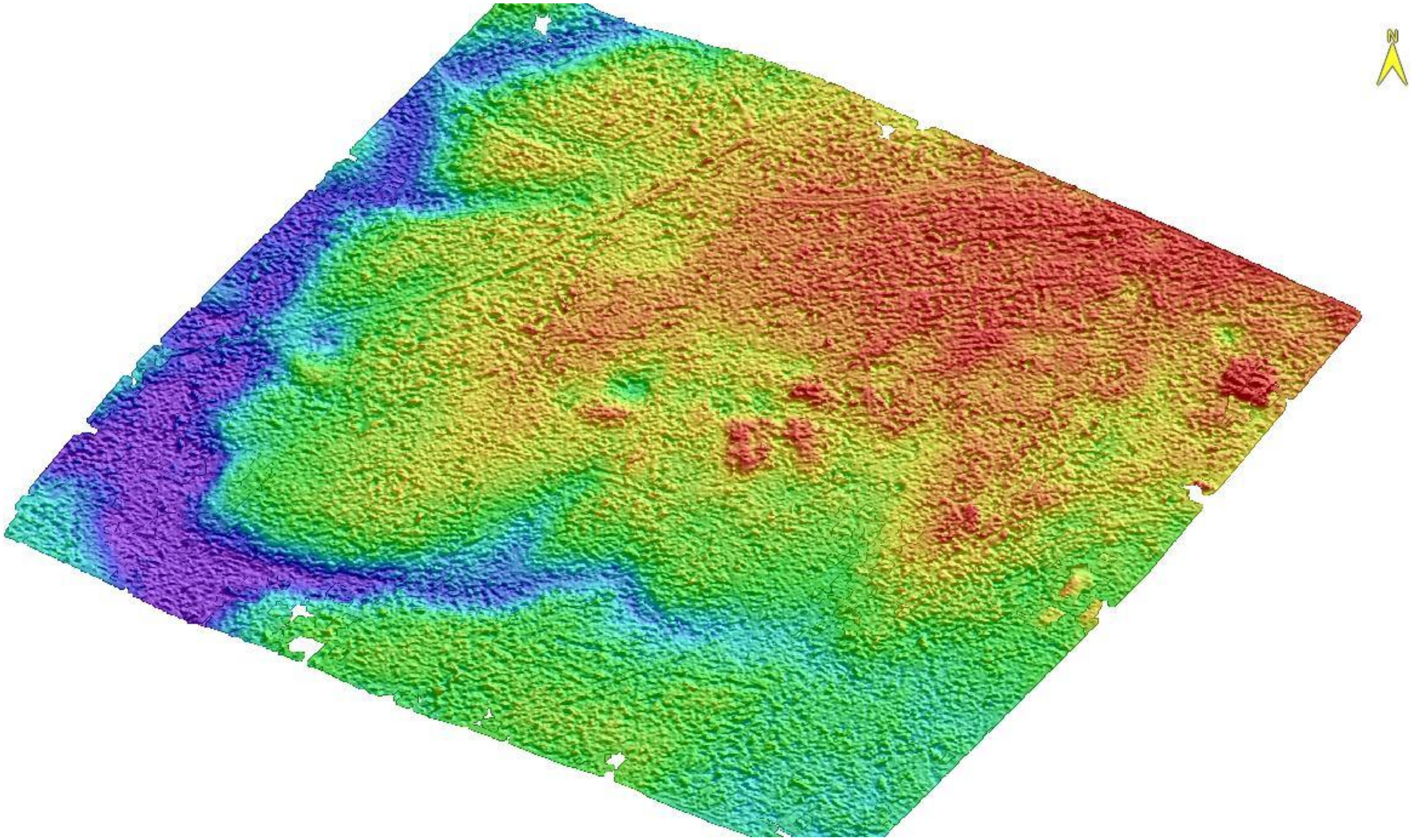




ILU

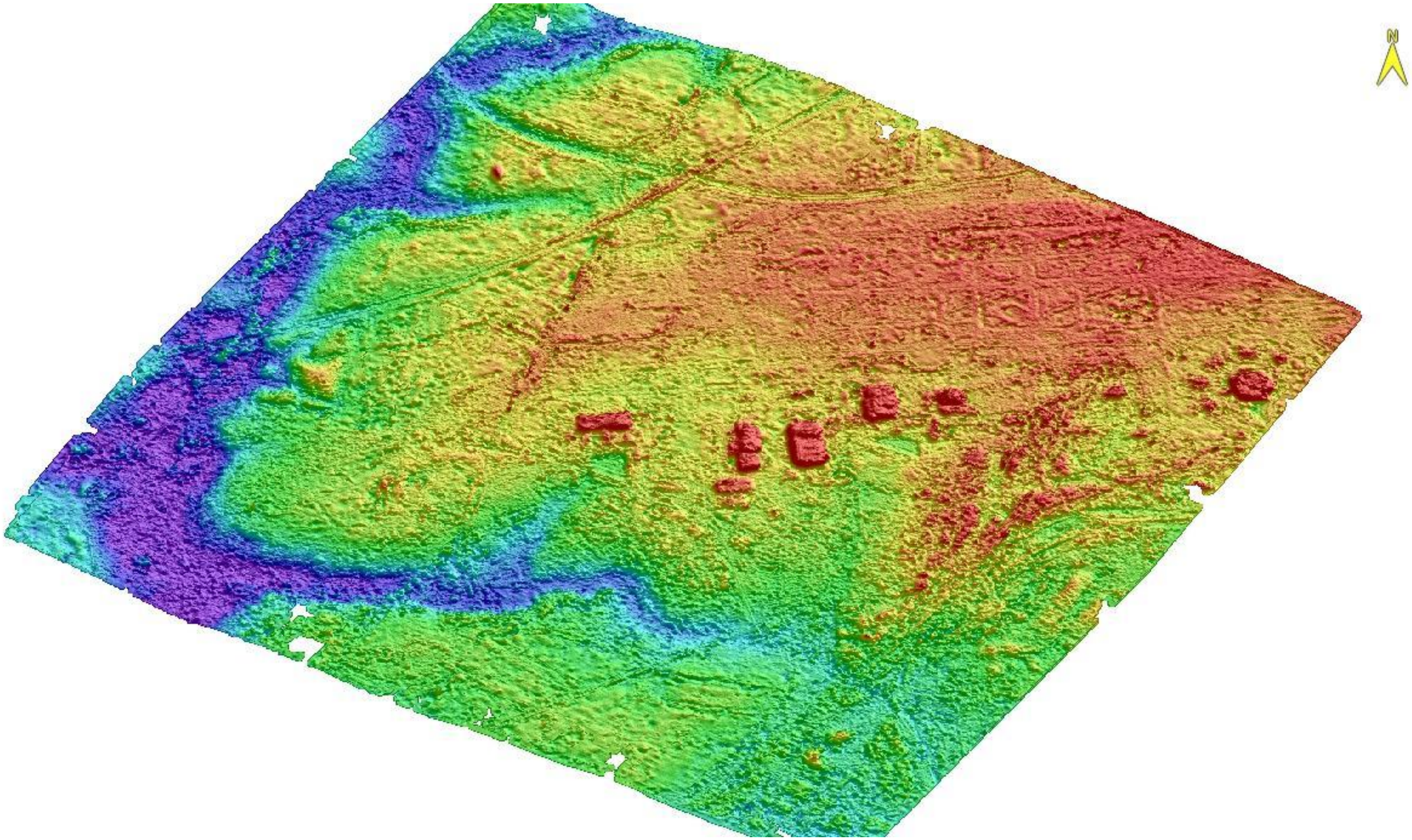
LuTan-1 bistatic interferometry

New & VHR sensors: revival of stereo



5m-posting reference DSM

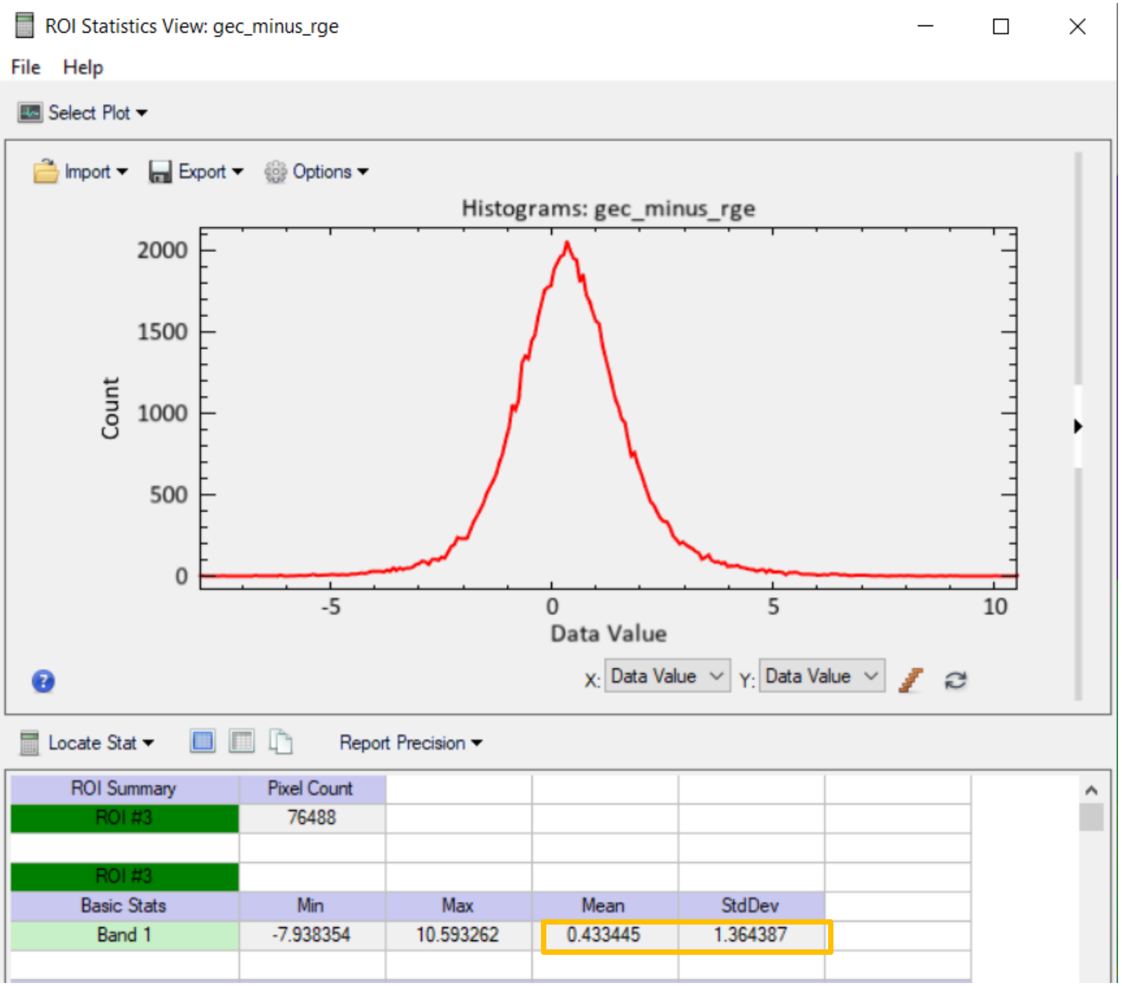
New & VHR sensors: revival of stereo



2m-posting stereo DSM from Capella GEC data

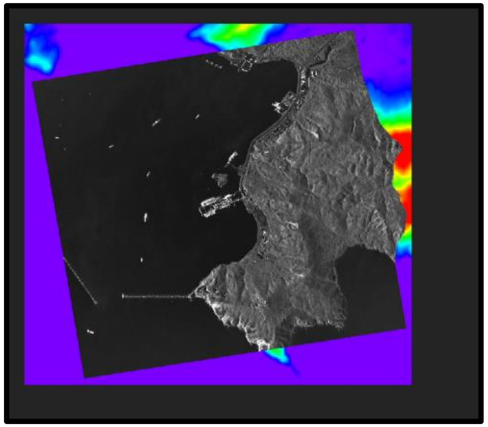
sarmap
your information gateway

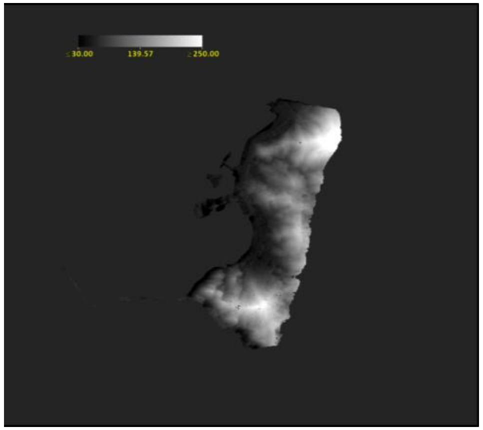
New & VHR sensors: revival of stereo



New & VHR sensors: revival of stereo – Capella + Umbra

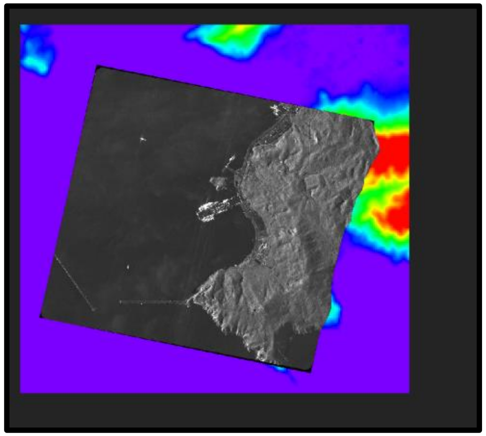
Capella

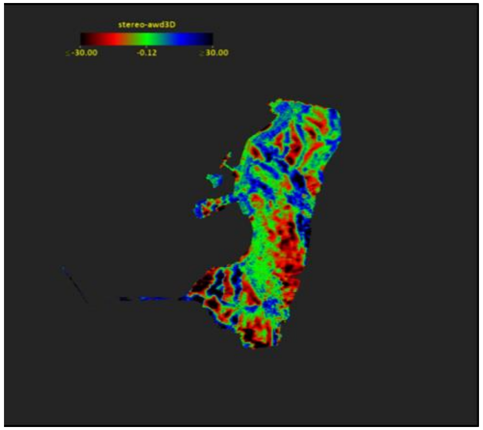




Stereo DEM

Umbra



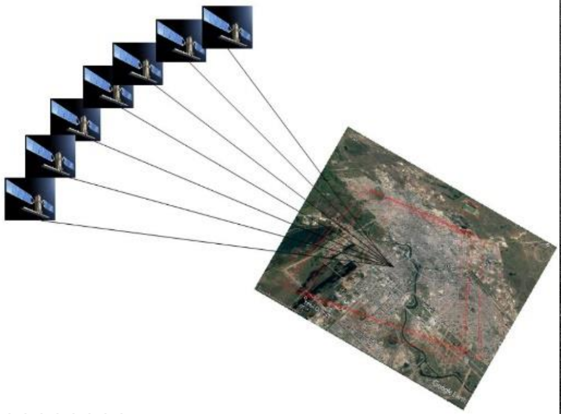


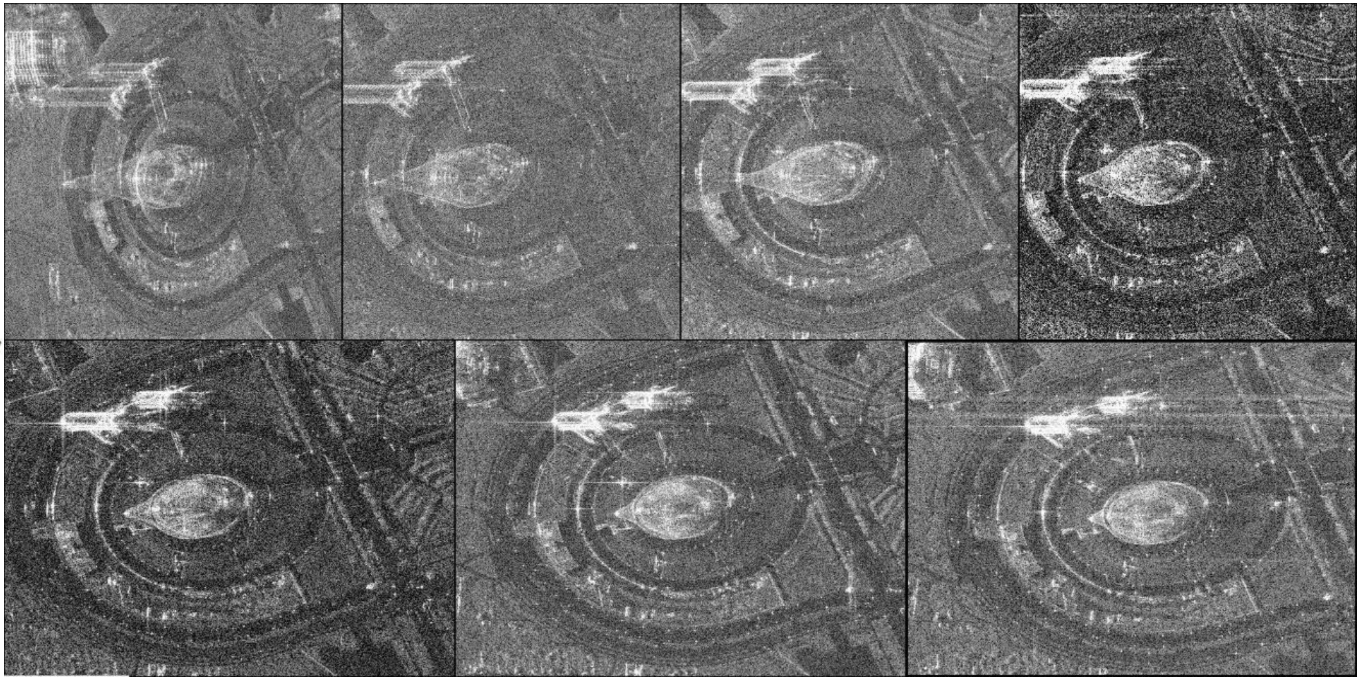
Stereo DEM –
Reference AW3D30

Absolute Incidence Angle difference = 9.77deg
Absolute Azimuth Angle difference = 20.89deg

Multi-stereo: the FanSAR approach

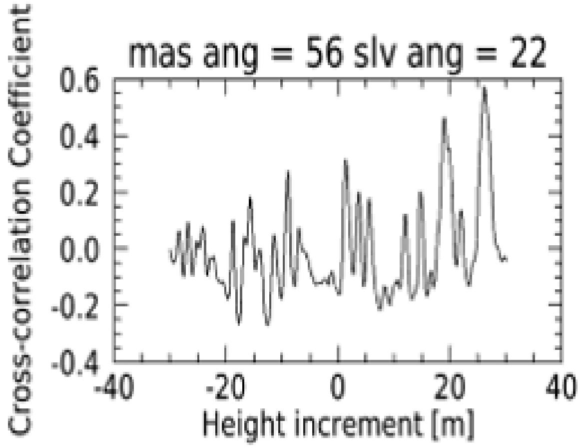
A multi-angular approach enables matching of large baseline pairs tracking the point along the SAR «fan».



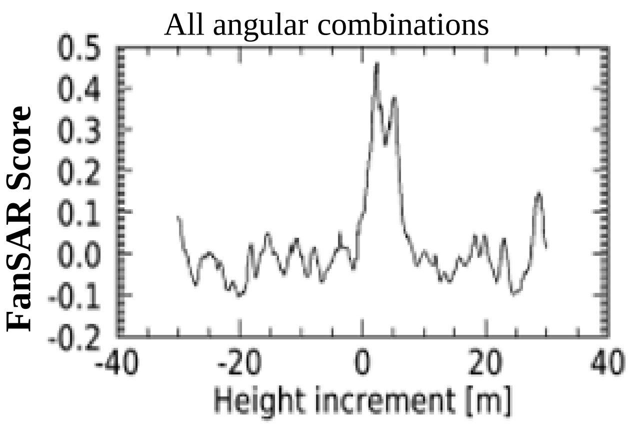


Cosmo-Skymed

FanSAR: Ability to Discard False Matchings



Stereo matching score on the single pair with largest angular difference



FanSAR joint multi-angular matching

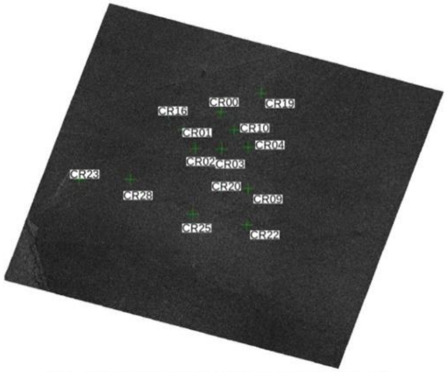
Cosmo-Skymed

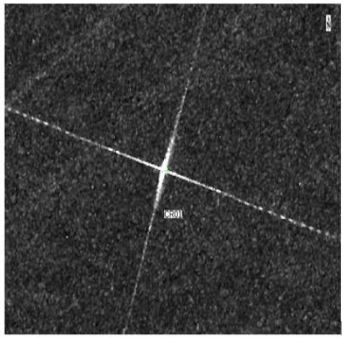
FanSAR: Validation with Corner Reflectors in ASI/CONAE Calibration site

- Statistical results of this validation show that the positioning absolute error is less than 1 [m].

- Mean error bias due to residual atmospheric component can be mitigated.

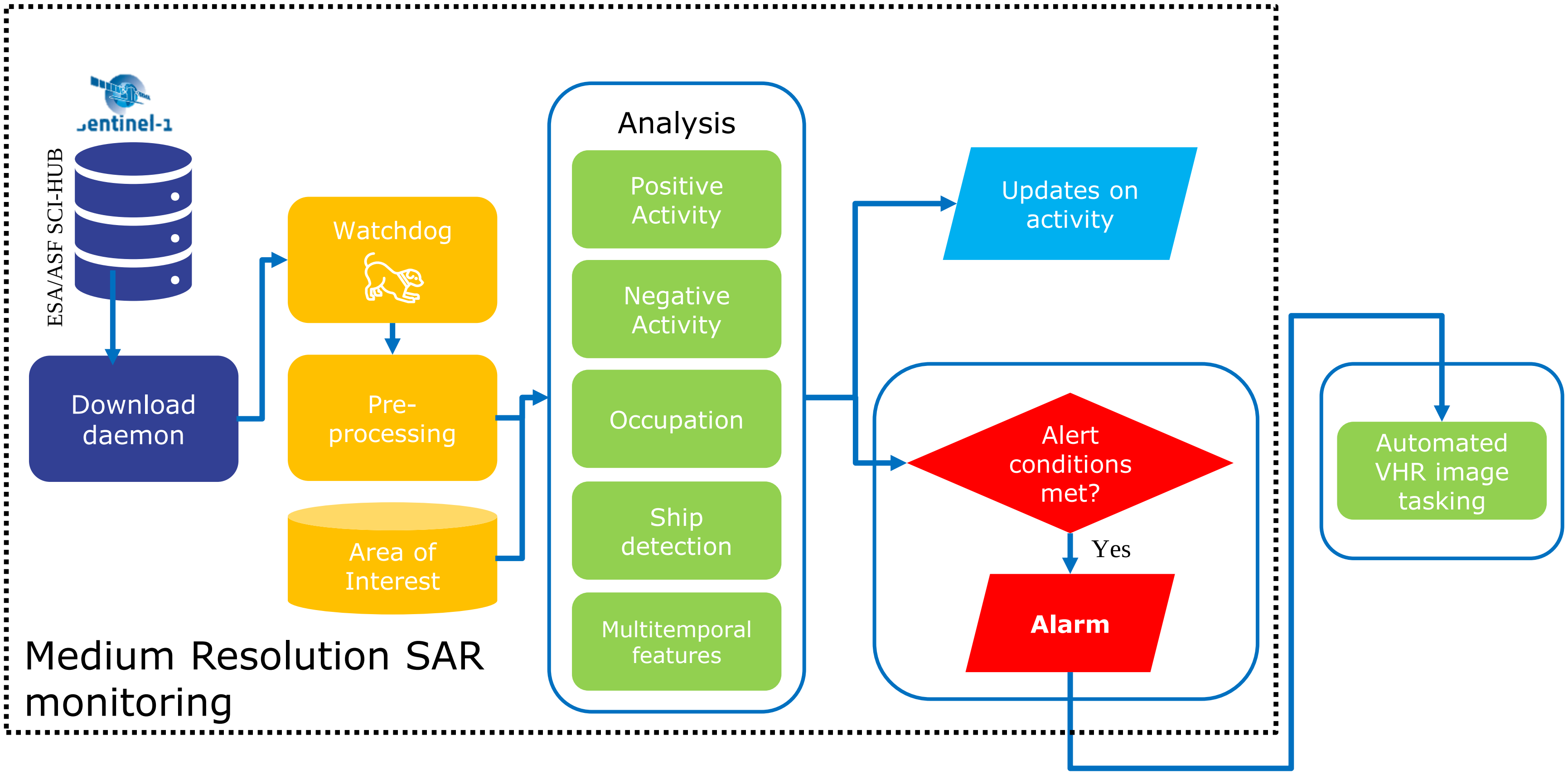
Test Area	El Sosneado
Number of CSK spotlight acquisitions	4
Number of processed points	14
Type of control points	SAR Trihedral
Mean horizontal error	0.71 [m]
Standard deviation of horizontal error	0.28 [m]
Root Mean Square Error	0.99 [m]
Mean vertical error	0.67 [m]
Standard deviation of vertical error	0.32 [m]
Root Mean Square Error	0.99 [m]



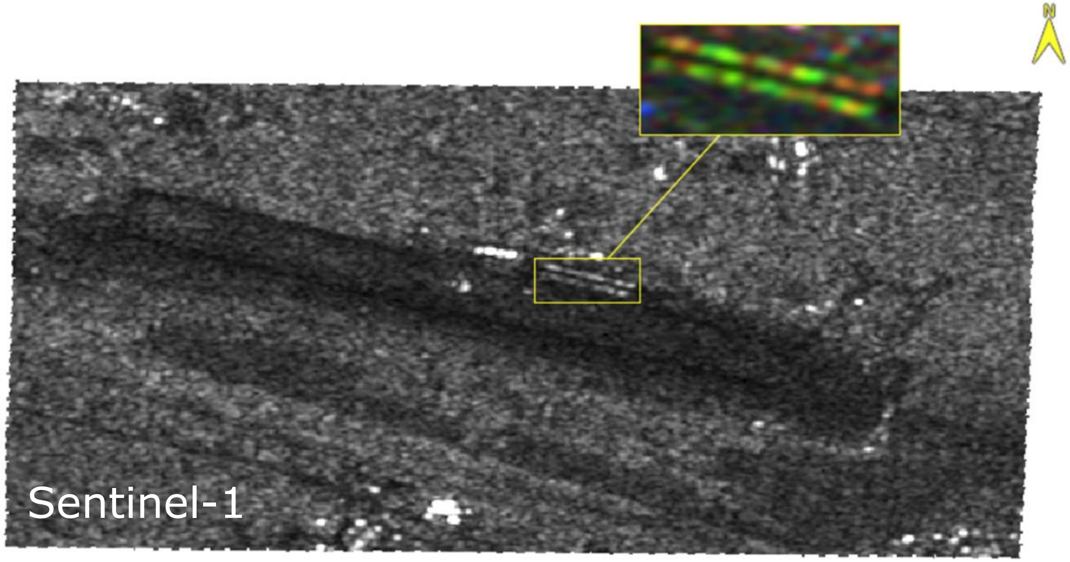


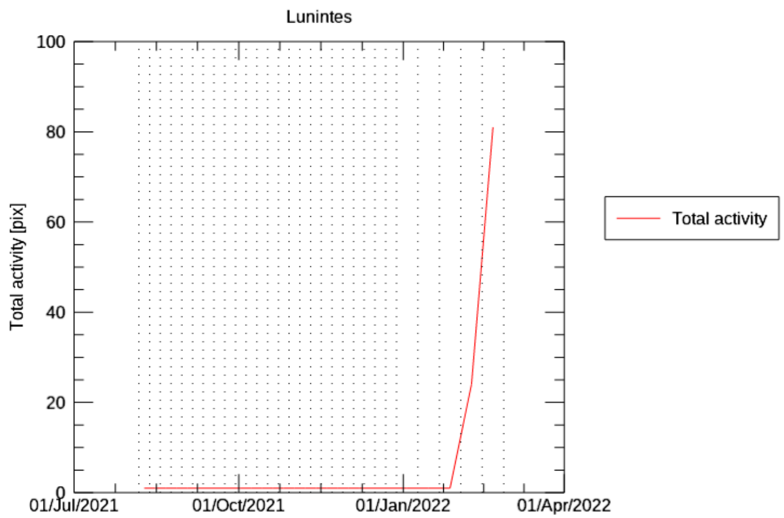
Cosmo-Skymed

New & VHR sensors: self-tasking API



Integration of MR and VHR images, automated tasking


Sentinel-1

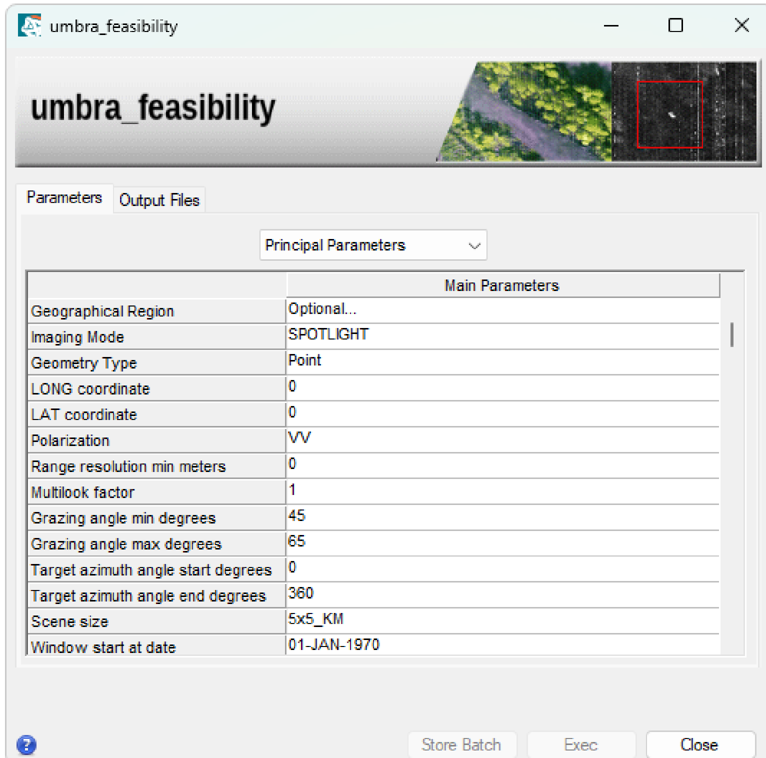


The magnification shows in green the arrival of airplanes between January 28 and February 9, 2022, and in red airplanes arriving from that date to February 21.

The same information can be automatically extracted from the activity index.


Capella, 19 February 2022

Umbra (and others) task & download

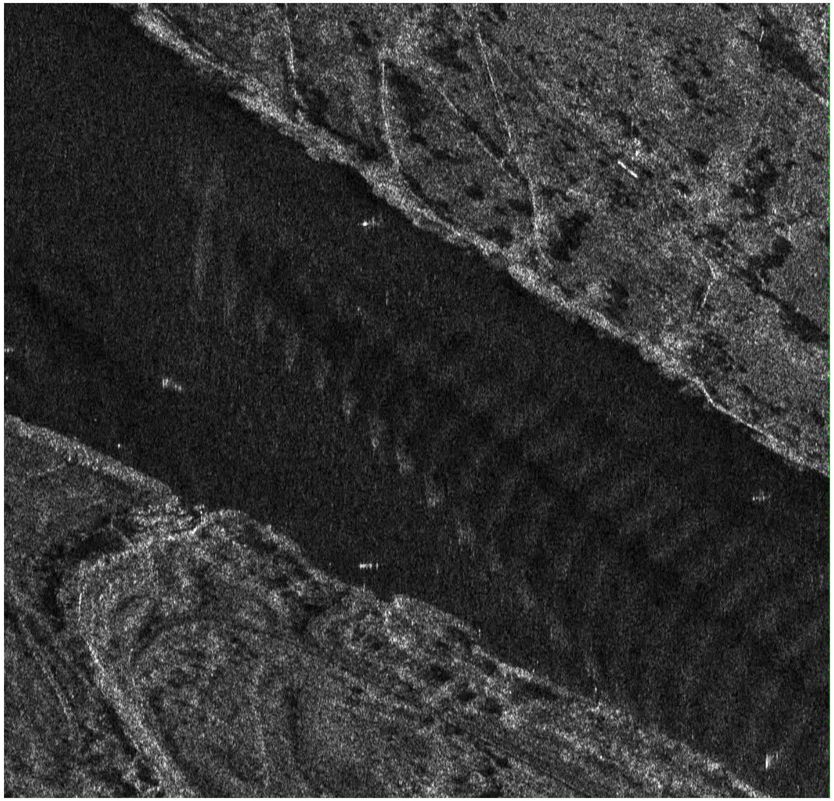


1) Feasibility analysis
2) Tasking request
3) Download

Further to come:

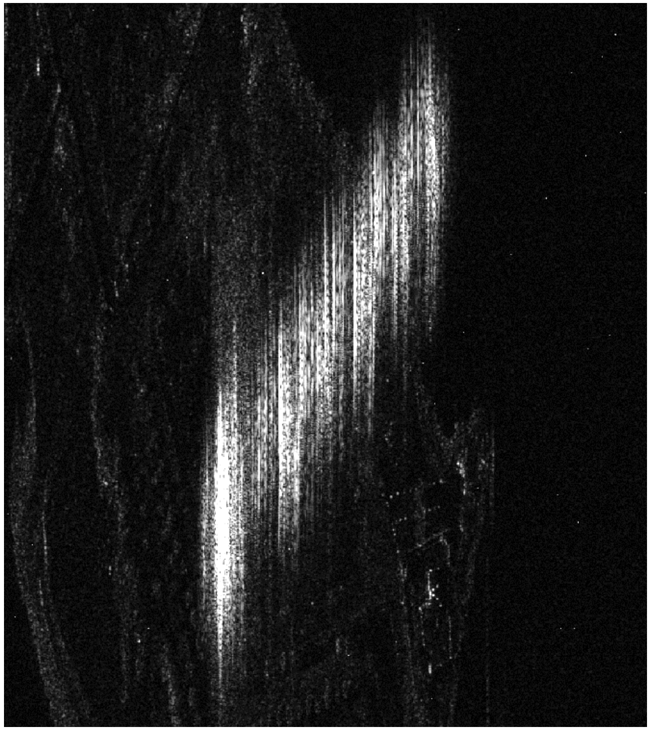
- Orbits propagation (prediction)
- Multi-tasking (CD-InSAR—Stereo pairs, sequences,…)

Long observation time: what happens during it?

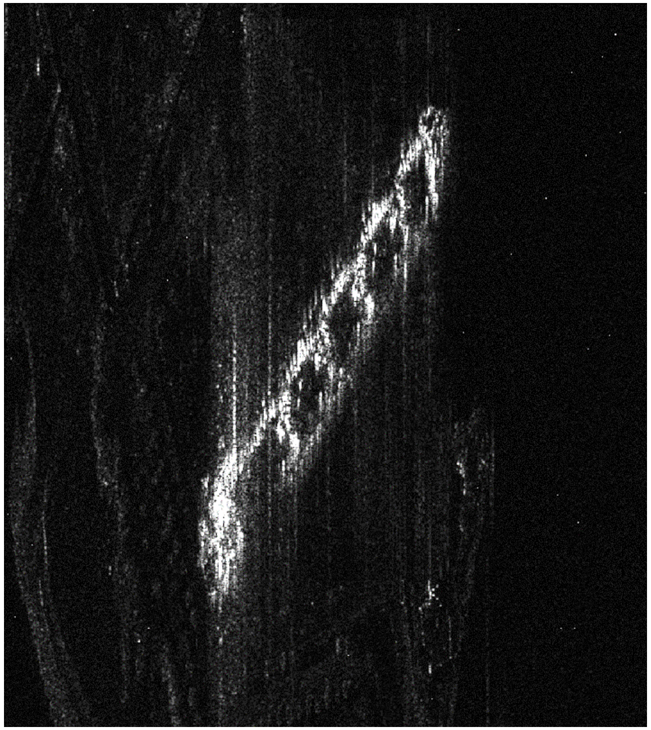


➔ Increasing interest in sub-aperture techniques:
- Inverse SAR - Moving Targets Indication
- Structural motion analysis

Thematic analysis: Inverse SAR / MTI



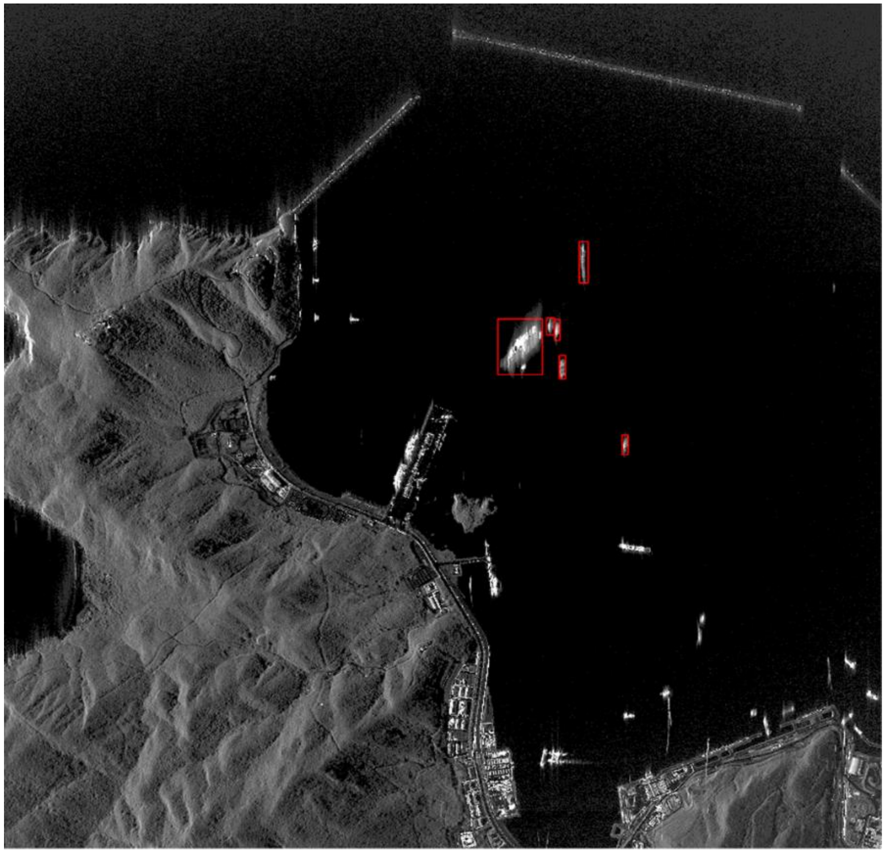
Defocused moving vessel
Suez channel



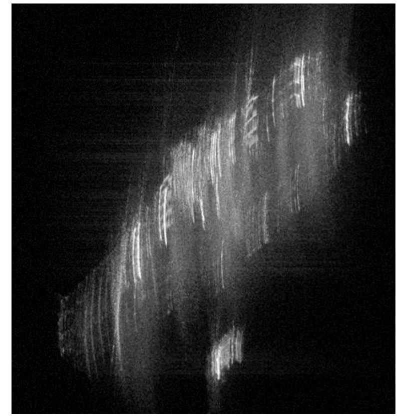
Refocused moving vessel
Bulk carrier
Estimated velocity: 7 knots

TerraSAR-X

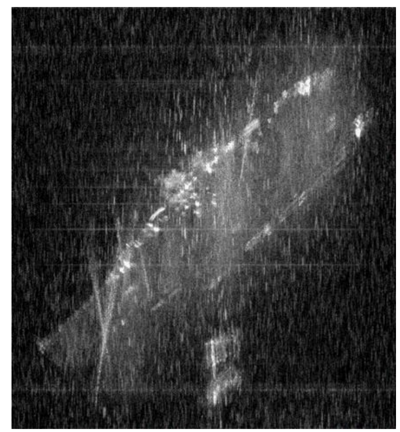
Thematic analysis: Inverse SAR / MTI



Automatically detected moving vessels



Defocused moving vessel



Refocused moving vessel Airplane carrier Estimated velocity: 3 knots

Capella

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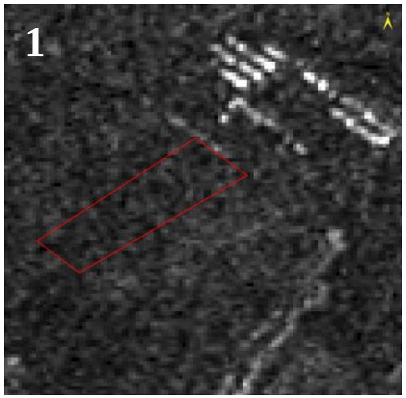
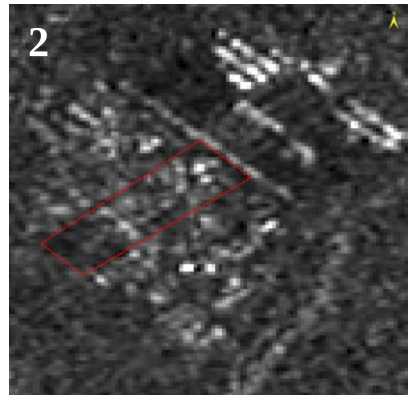
Thematic analysis – Occupation Index

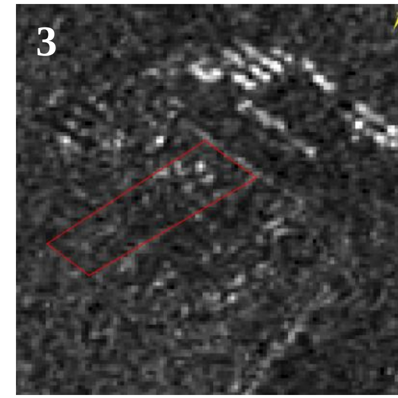
May 2019

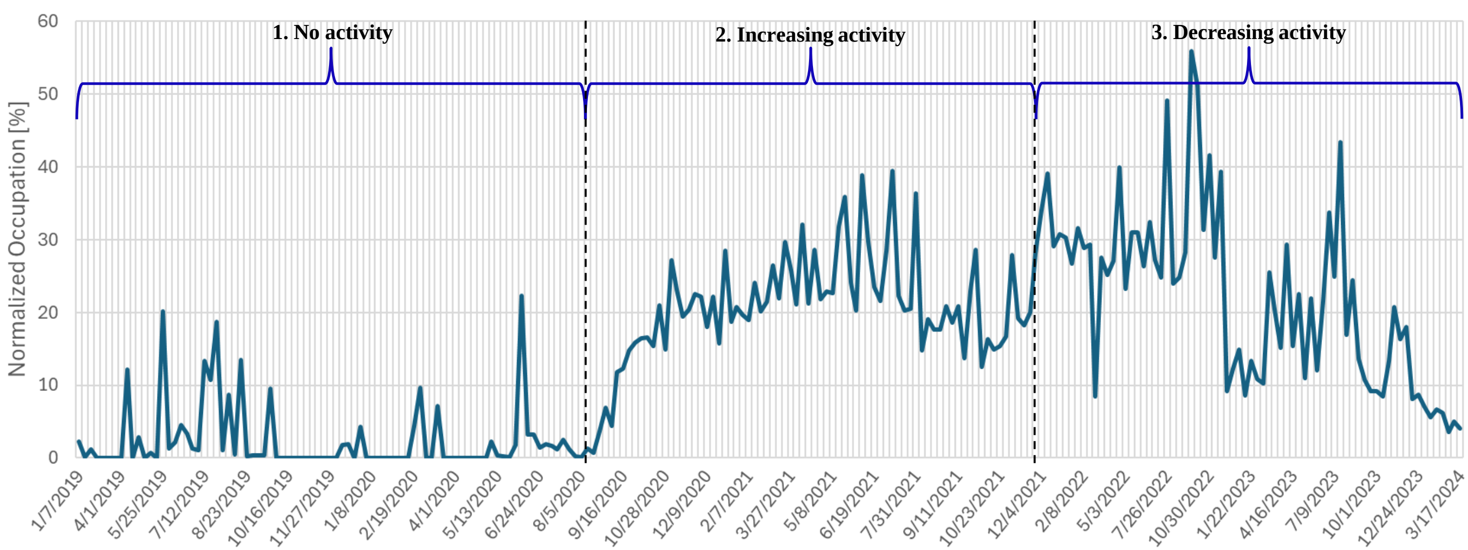


October 2022



June 2023



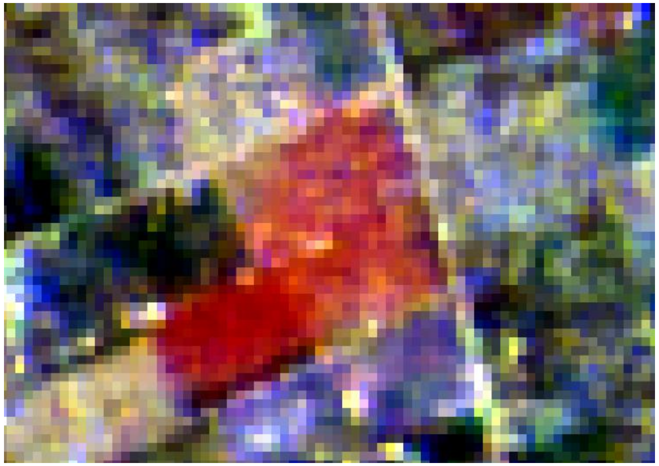


When Sentinel-1 resolution is not enough to monitor single objects

Thematic analysis

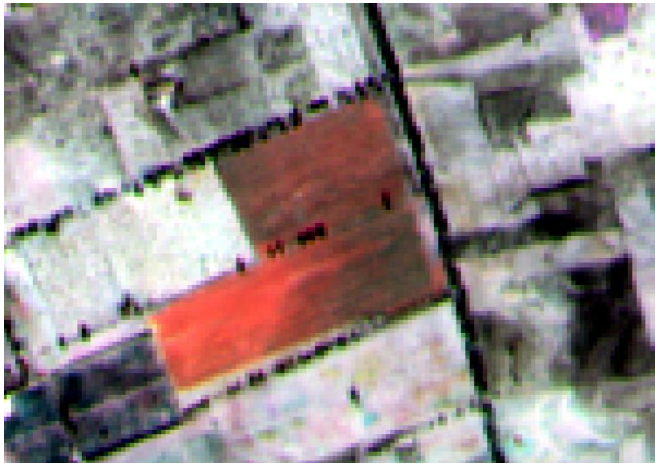
Google Earth

Sentinel-1 ACD



Sentinel-1 CCD

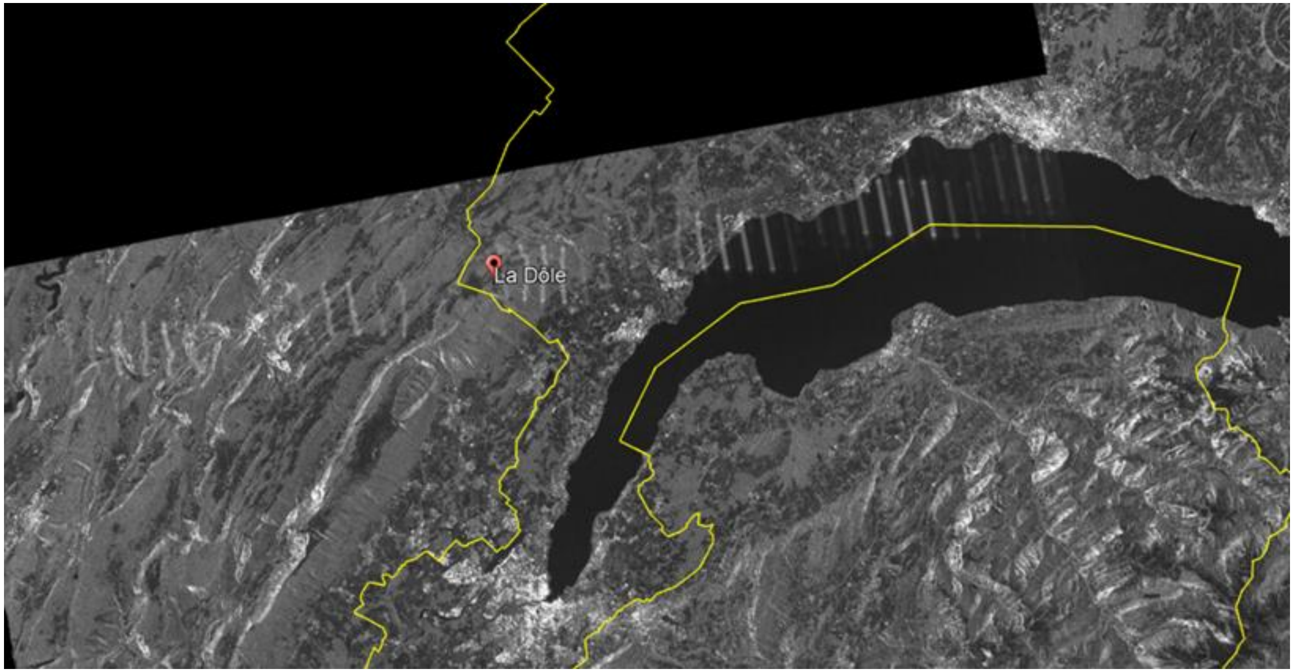
Sentinel-2 CD



Burial sites – mass graves

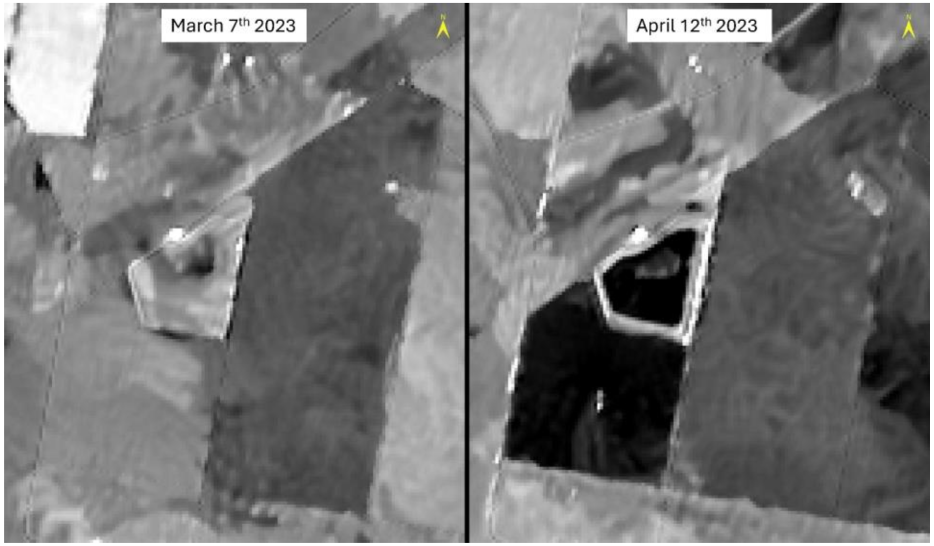
Leveraging the experience from ESA EVIDERI project in support of the International Court of Crimes

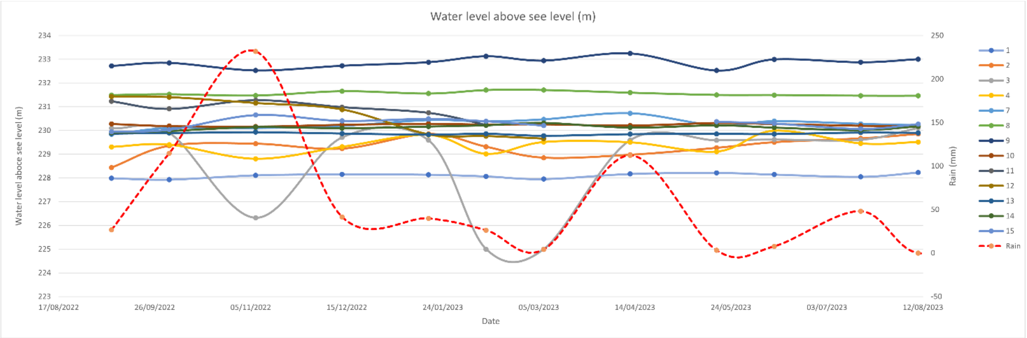
Thematic analysis: identification and parametrisation of ground transmitters



Parameter	Mean measured value	Expected Value	Mean difference	Standard Deviation
Carrier Frequency [MHz]	5’430.5	5’430	0.5	0.2
Bandwidth [MHz]	3.03	2.52	0.51	0.18
Duration [ns]	477	500	23	15
Pulse Repetition Frequency {Hz]	899.8	900	0.2	0.1
Easting [m]			1’209	6’432
Northing [m]			56	799

Thematic analysis: water bodies monitoring

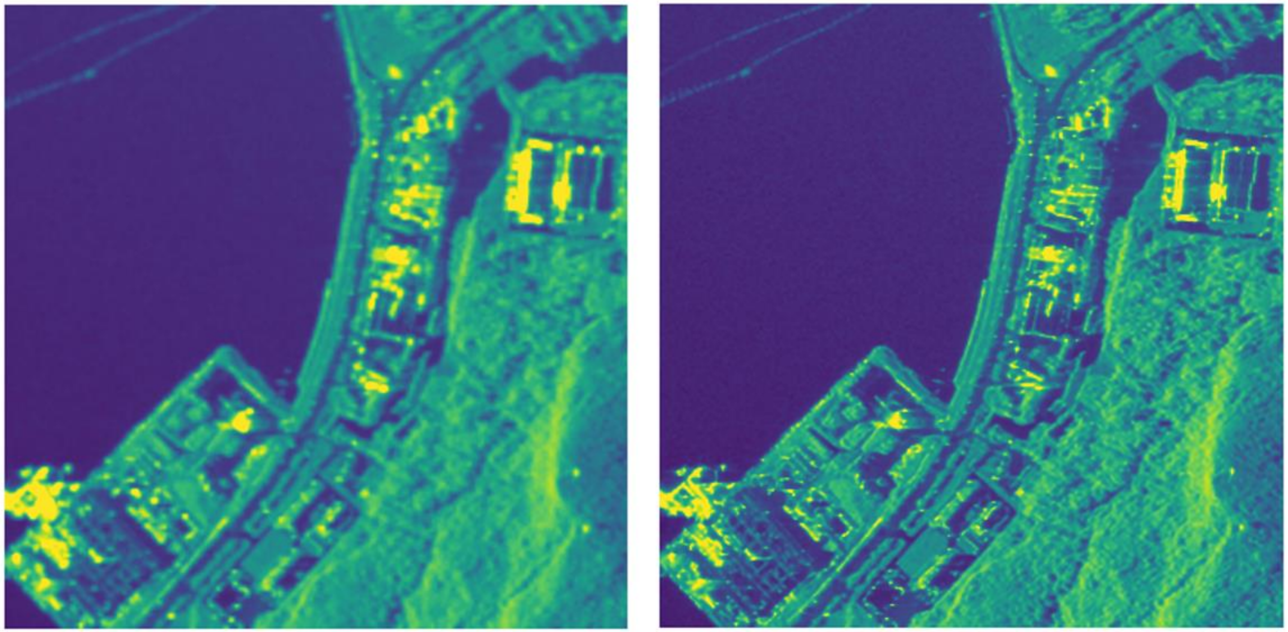




Thematic analysis

Other (DL-based) topics in progress:

- Super-resolution
- Single-image urban DEM
- Image coloring

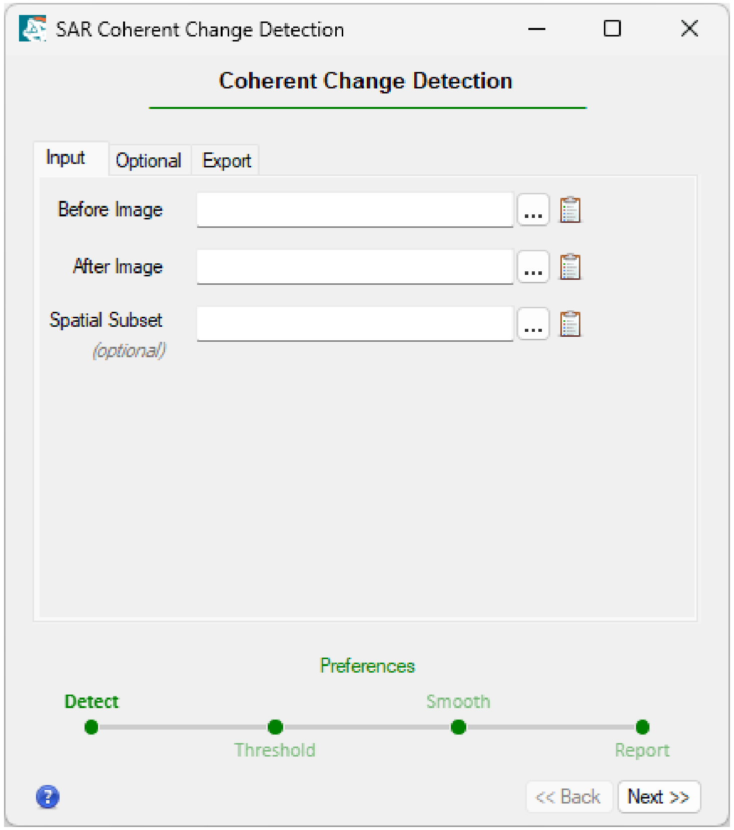


4X4

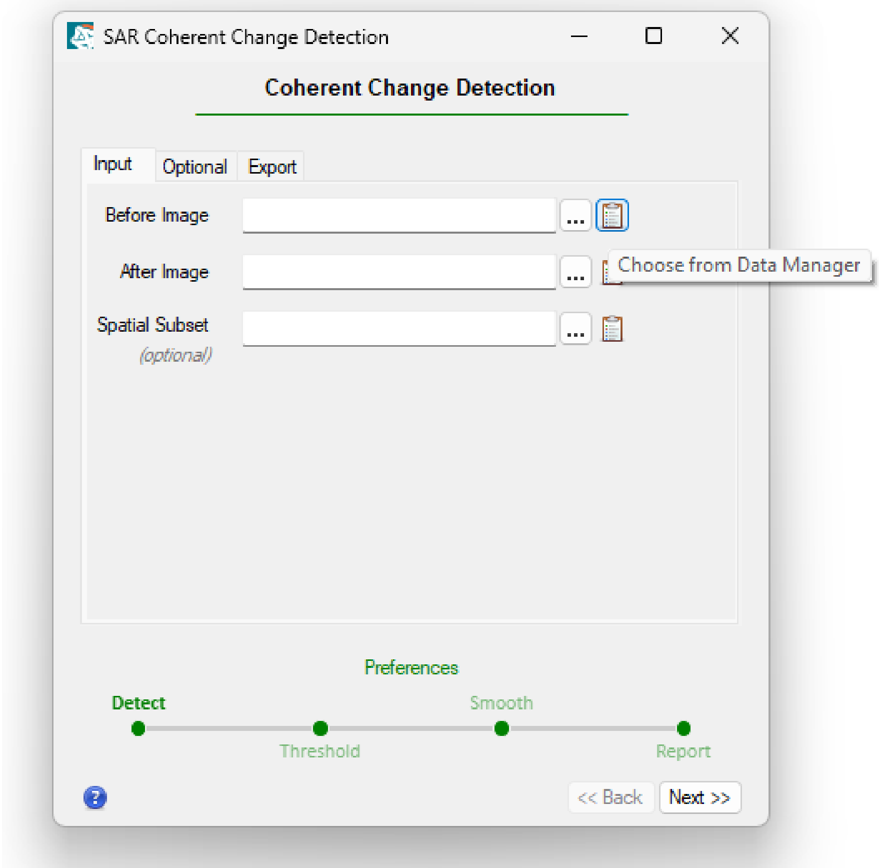
Continuous refactoring

- Stereo
- Geocoding
- Focusing (CPHD, time-domain,..)
- Amplitude tracking
- Polarimetry
- …

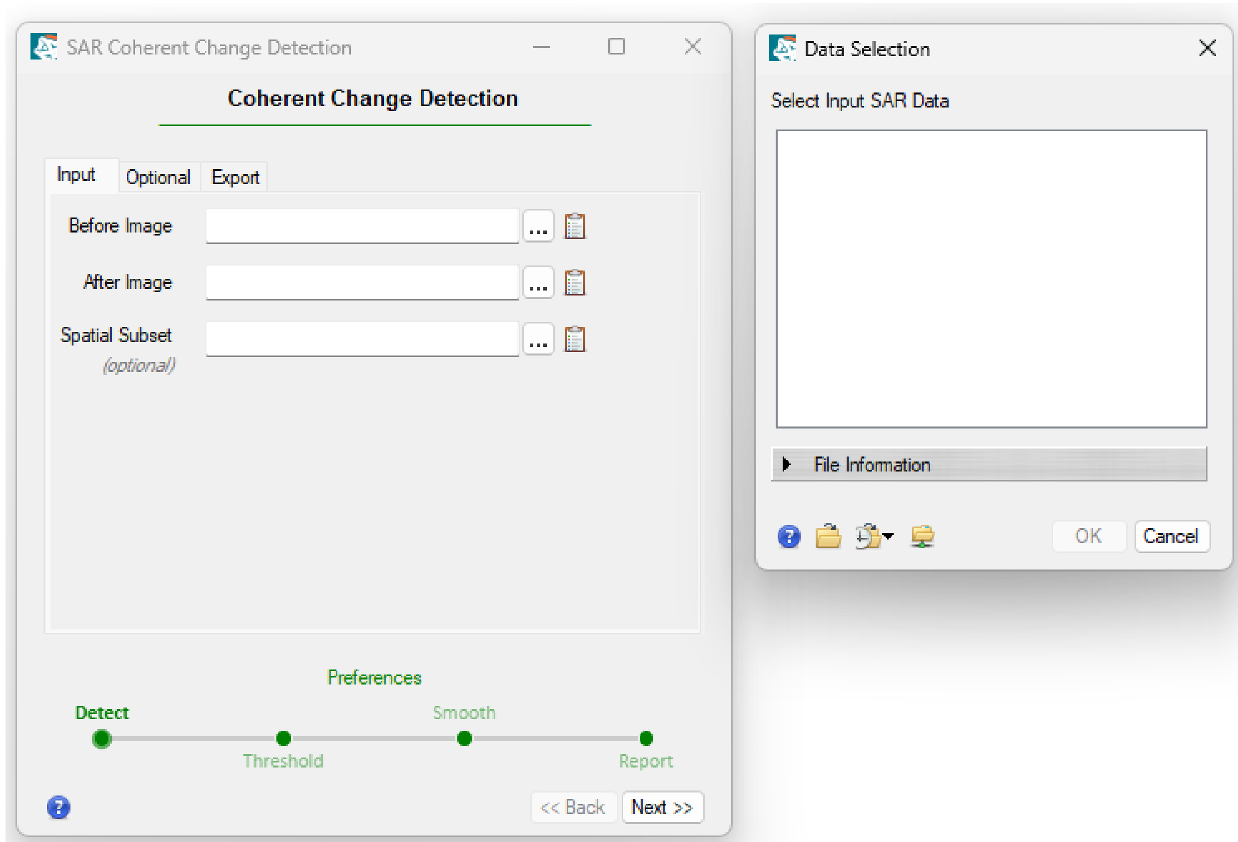
Continuous closer integration with ENVI



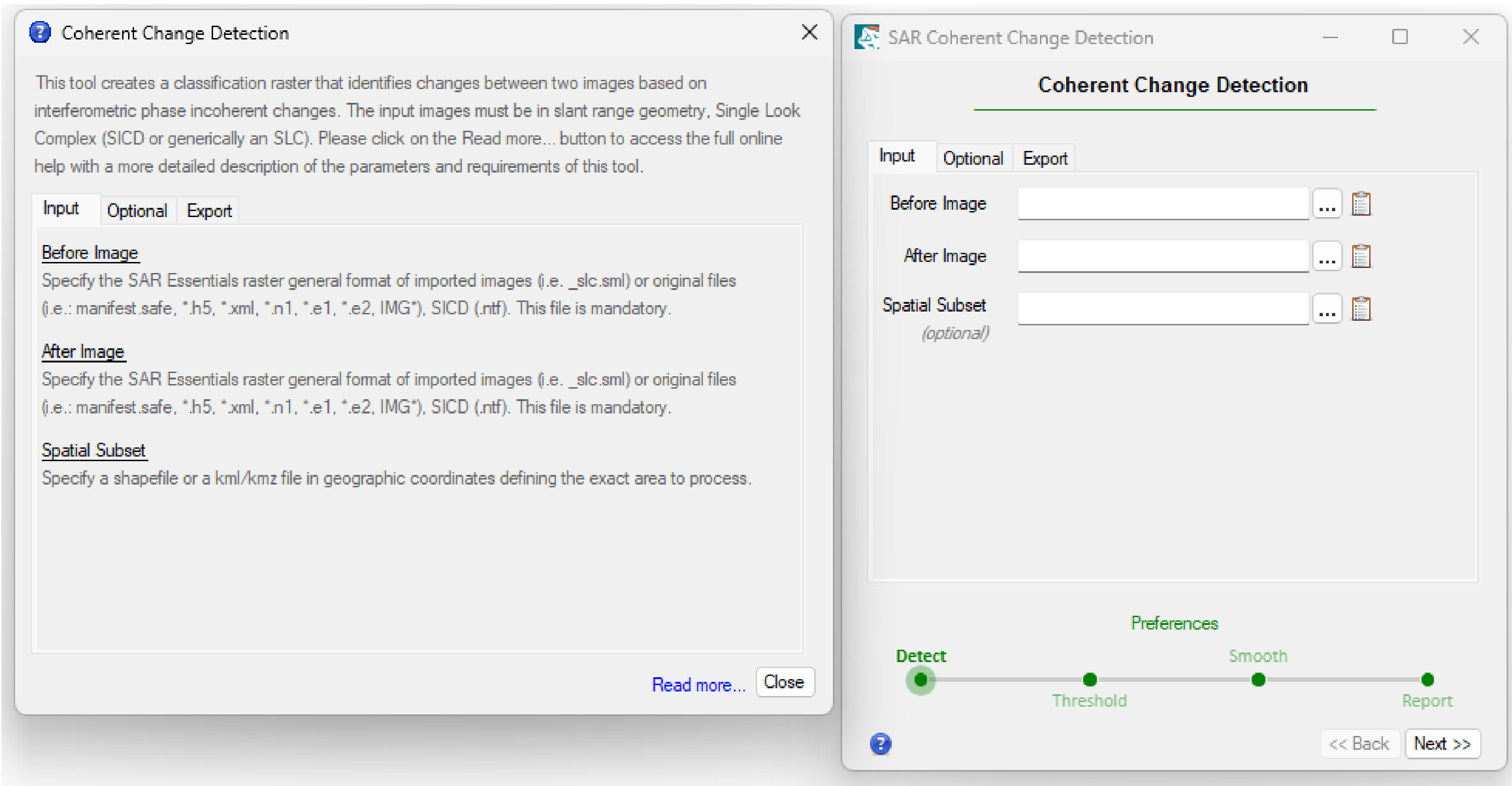
Continuous closer integration with ENVI



Continuous closer integration with ENVI



Continuous closer integration with ENVI



どうもありがとうございます!