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Asi-Sisma Presentations

CRIPPA B.

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The use of the DInSAR technique in the SISMA project

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General scheme for calculating velocity of movements and displacements

DIAPASON
(V1-SISMA)

↓

Generation of the differential interferograms

VELLIN
(V2-SISMA)

↓

Calculation of velocity of movement based on a linear model

Work phases in the SISMA project

V1

- Acquisition of the SAR images over test area
- Optimization procedures for the creation of the interferograms

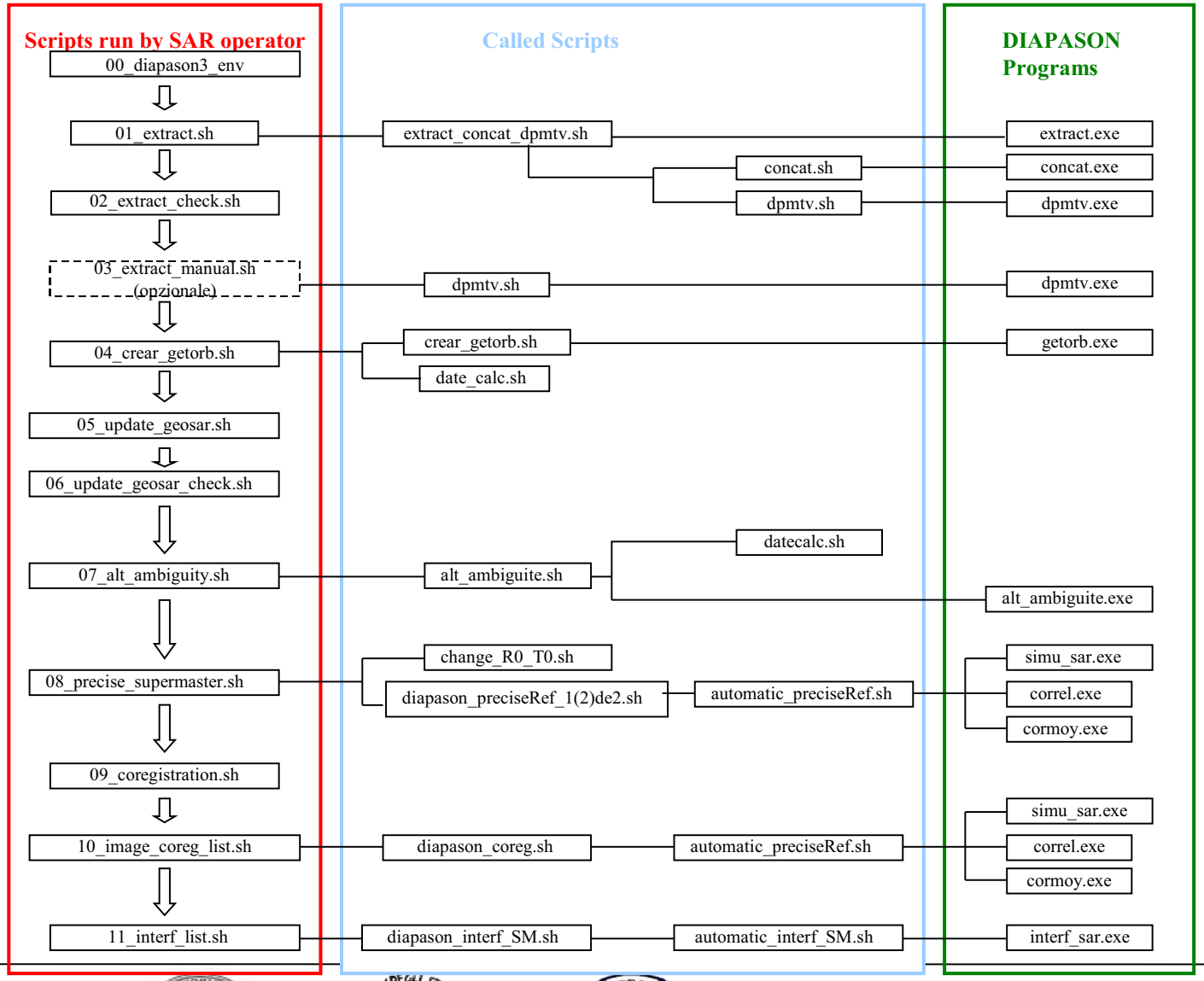
V2

- Implementing procedures for analysis focused on active fault alerted
- Implementation and optimization algorithms to estimate movements and velocity of movements

DInSAR Procedure V1

Principal steps of the DInSAR procedure (AUX_DIA):

1. SAR image and precise orbit acquisition
2. Acquisition of the DEM in the three test areas
3. SuperMaster image calibration (reference geometry of the stack)
4. Coregistration of the images respect to SuperMaster (creation of images stack)
5. Differential interferogram calculation (creation of interferogram stack)
6. Calculation of the images: coherence, incident angle, perpendicular baseline

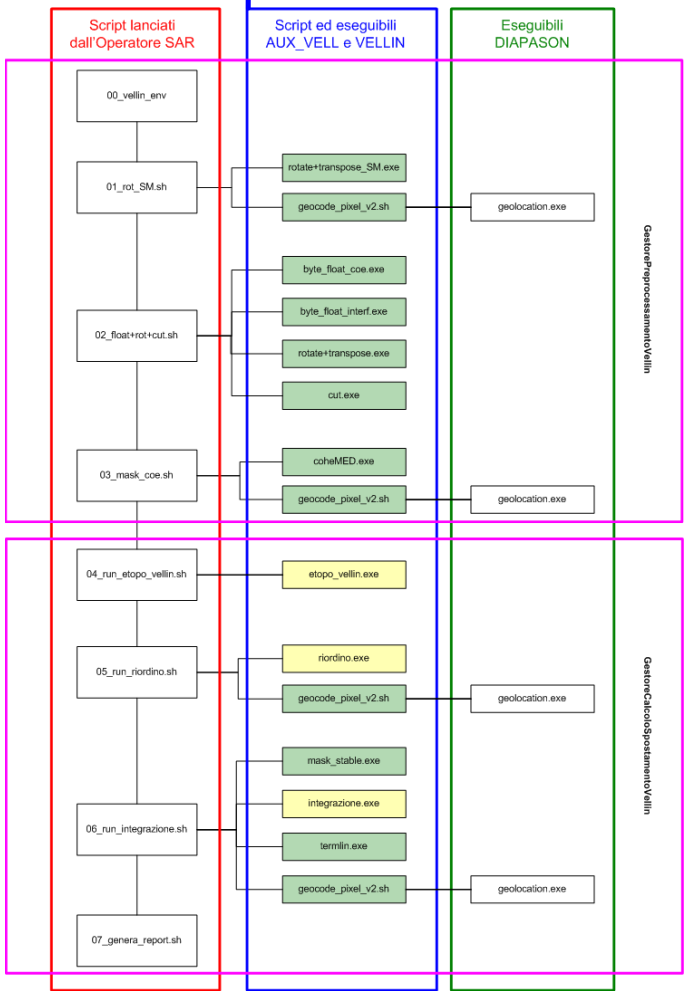

Scripts run by SAR operator
Called Scripts
DIAPASON Programs
00_diapason3_env
01_extract.sh
02_extract_check.sh
03_extract_manual.sh (opzionale)
04_crear_getorb.sh
05_update_geosar.sh
06_update_geosar_check.sh
07_alt_ambiguity.sh
08_precise_supermaster.sh
09_coregistration.sh
10_image_coreg_list.sh
11_interf_list.sh
extract_concat_dpmtv.sh
concat.sh
dpmtv.sh
dpmtv.sh
crear_getorb.sh
date_calc.sh
datecalc.sh
alt_ambiguite.sh
change_R0_T0.sh
diapason_preciseRef_1(2)de2.sh
automatic_preciseRef.sh
diapason_coreg.sh
automatic_preciseRef.sh
diapason_interf_SM.sh
automatic_interf_SM.sh
extract.exe
concat.exe
dpmtv.exe
dpmtv.exe
getorb.exe
alt_ambiguite.exe
simu_sar.exe
correl.exe
cormoy.exe
simu_sar.exe
correl.exe
cormoy.exe
interf_sar.exe

VELLIN and AUX_VELLIN V2

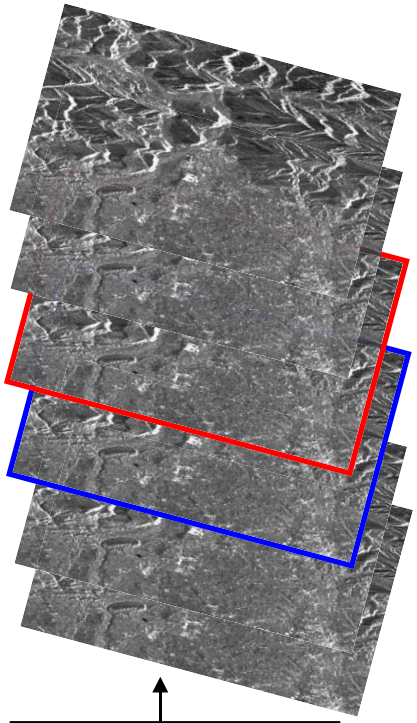
Principal steps of the VELLIN procedure (AUX_VELLIN):

- selection of pixels using coherence images
- calculating velocity and topography error on pairs of pixels
- building a network of connected edges
- reconstruction of velocity and topographic error by integration over the edges of the network

Overview of components of Vellin and AUX_VELL

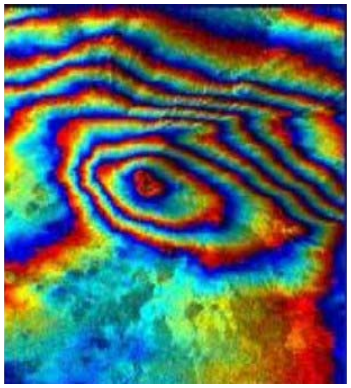


Differential interferometry SAR



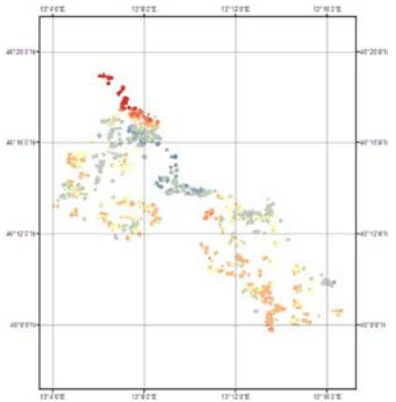
Images Stack

V1



Differential interferograms stack

V2



Velocity map

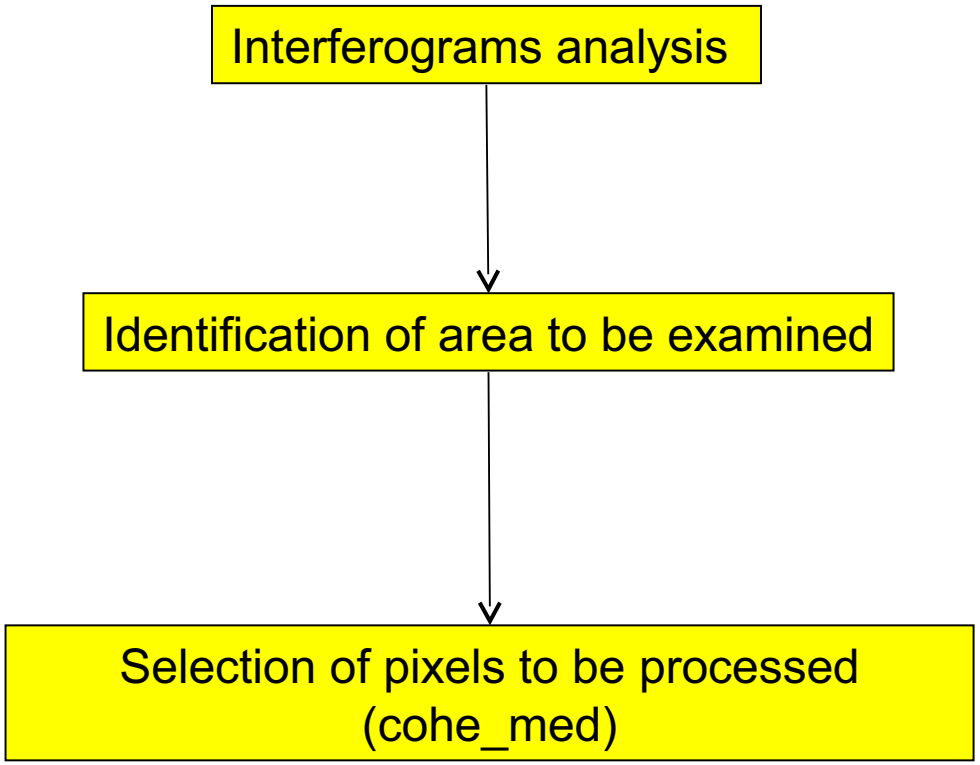
$$\Delta\varphi = \Delta\varphi_{FLAT} + \Delta\varphi_{ELEV} + \Delta\varphi_{MOT} + \Delta\varphi_{ATM} + \Delta\varphi_{NOISE}$$

Activities of the V2 stage of the SISMA project

1. Developing algorithms implemented in C language to estimate the displacements and the linear velocity of movements, called Vellin module

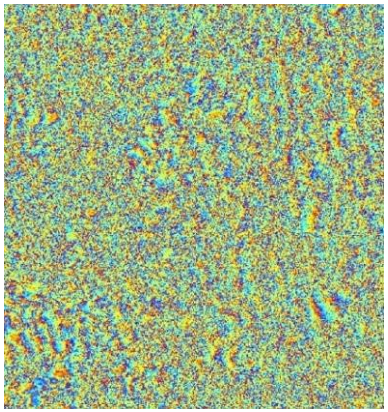
2. Developing algorithms implemented in C and bash script to run the Vellin module and management of the data in relation to active fault alerted, called module AUX_VELL

Vellin Pre-processing

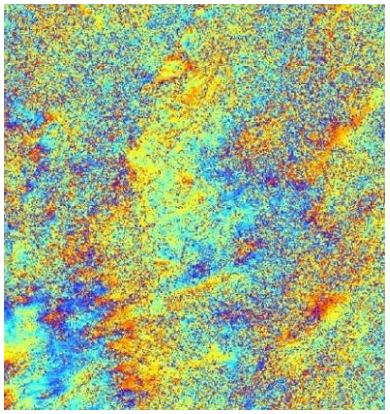


Interferograms analysis

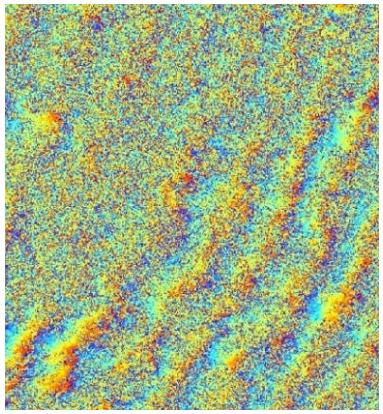
The interferograms produced by the SW DIAPASON (managed with AUX_DIA module) can be characterized by a different features



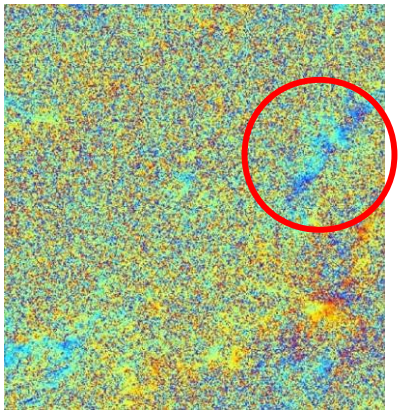
Noise



Possible atmospheric effect



Orbital error



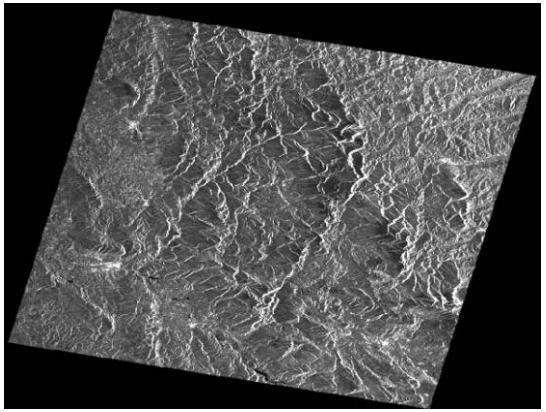
Possible signal

Operator's task is to remove the SAR interferograms with noise, atmospheric and orbital errors to ensure the reliability of the estimated linear velocities

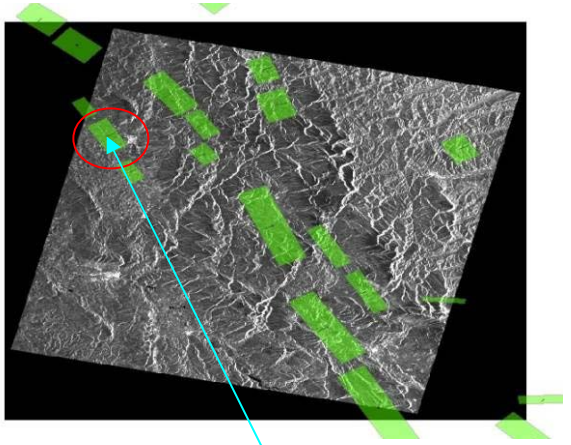
Identification on SAR amplitude image of the alerted fault.

Image in the original SAR geometry

Georeferenced image



Superimpose DISS DB on Georeferenced image

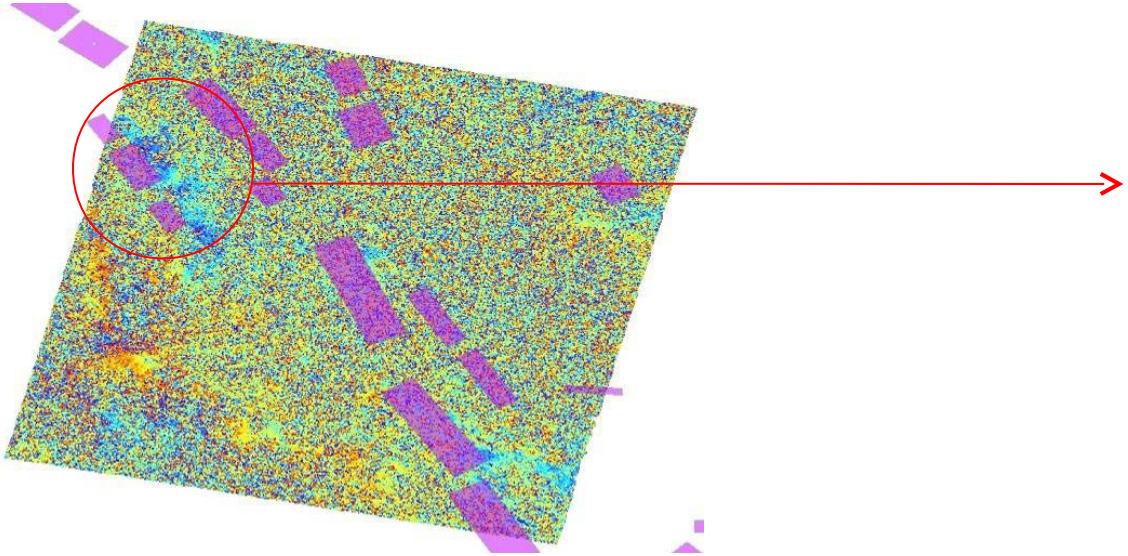


The operations are carried out with:

- Geocode_pixel_v2.sh algorithm: an algorithm implemented for georeferencing
- SW Arcgis 9.3: graphic support

Crop interferograms on active fault alerted

Cropping is done in order to work on a smaller area to increase the efficiency of calculation

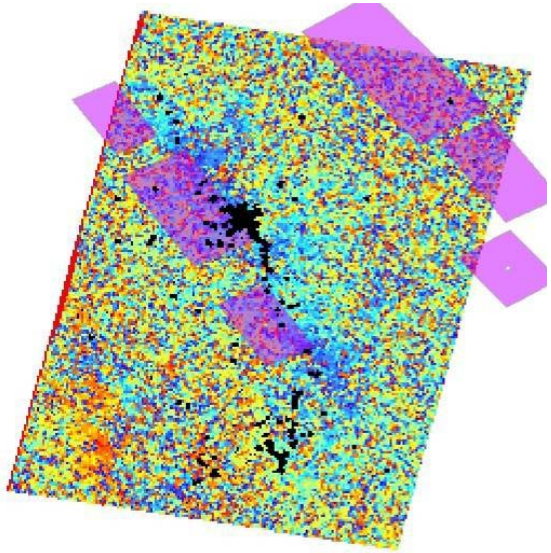


Implemented algorithms:

- byte_float.c: transformation format byte to float
- rotate+transpose.c: interferograms in more readable geometry
- cut.c: crop inteferogram on area of analysis

Selecting the pixels to be processed

The estimate of velocity should be performed only on pixels with high coherence in order to obtain a good reliability of the estimates (blacks points in the figure). These pixels are selected using the stack of coherence images.

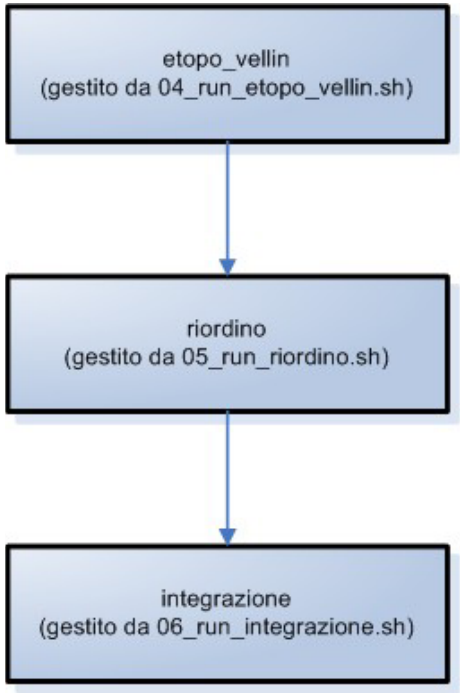


Implemented algorithms :

- 03_mask_coe.sh
- coheMED.c

Processing steps: estimating linear velocities and displacements

The estimation of linear velocities and displacements is performed by three different algorithms, each with specific features:



Etopo_vellin

(Code implemented in C language)

Estimation of "topography error" and linear velocities on differential pairs of pixels characterised by high coherence

Linear model used:

$$\Delta\phi\left(\Delta v(e), \Delta te(e)\right) = \frac{4\pi}{\lambda}\Delta T \Delta v(e) + \frac{4\pi}{\lambda}\frac{B_{\perp}}{R\ \mathrm{sen}\theta}\Delta te(e)$$

The solution (estimation of Δv, Δe) is based on maximization of temporal coherence:

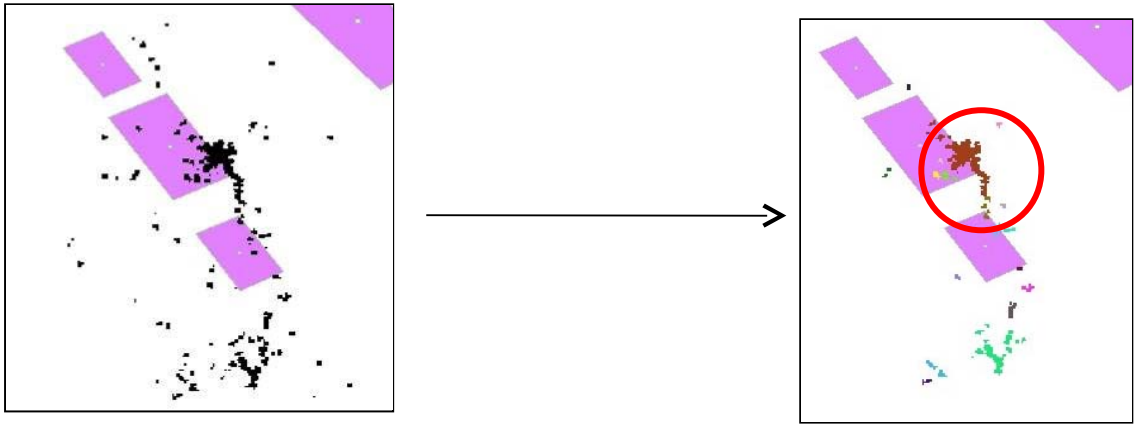
$$\gamma(e) = \frac{1}{N}\left|\sum_{k=1}^{N} \exp\left(j \cdot \left(\Delta\phi_{obs}^{N}(e) - \Delta\phi_{\mathrm{mod}}^{N}\left(\Delta v(e), \Delta te(e)\right)\right)\right)\right|$$

N=number of interferograms

Riordino

(Code implemented in C language)

Selection and grouping of the pairs of pixels (edges) where the function γ is above a fixed threshold (constraint for goodness of estimate)



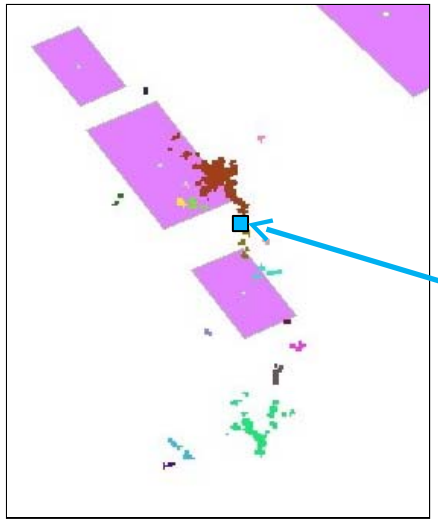
The SAR operator identifies the group of pixels which fall in the area of the fault

Integrazione

(Code implemented in C language)

Least squares compensation for calculating the linear velocity and displacement with respect to a reference point.

Shifts are calculated using the relation s = Dt * vlin



STABLE ZONE (fixed by SAR Operator)

- It is usually known using external information
- Fixed outside the fault plane (assuming it is a stable area)

Production of velocity and displacement maps

The final products at the end of VELLIN-AUX_VELL procedure are:

- linear displacement map
- linear velocity map

Georeferenced maps are provided in WGS84 reference system, the georeferencing is performed using an algorithm developed in bash (geocode_pixel_v2.sh) routine that uses the SW DIAPASON geocoding

The maps are provided in a format compatible with the SW Arcgis 9.3 which can be imported for display.

The products are accompanied by a descriptive file that contains the time interval to which it refers, the number of orbits of the images used, the sensor which has been obtained and the identification of fault analyzed.

Validation strategy SW VELLIN

The VELLIN software (etopo_vell, riordino, integrazione) has been validated by means of simulations:

1. Using a stack of interferograms taken from a real case study (to obtain baseline information on temporal and perpendicular geometric parameters)

2. Simulation of a linear velocity field

3. Production of a stack of synthetic interferograms from simulated velocity field with additional term like noise, atmospheric effects, etc.

4. Applying the Vellin procedure to calculate the linear velocity

5. Comparison between the simulated velocity (known a priori) and the velocity estimated through a test based on normal distribution

Validation of Vellin

- Simulated velocity field compatible with that induced by a normal fault type of setting boundary conditions

- reconstructed interferograms (size 460 columns x 510 rows)

- the percentage differences between estimated speed and speed simulated in the range [-1.96, 1.96] is greater than 95%

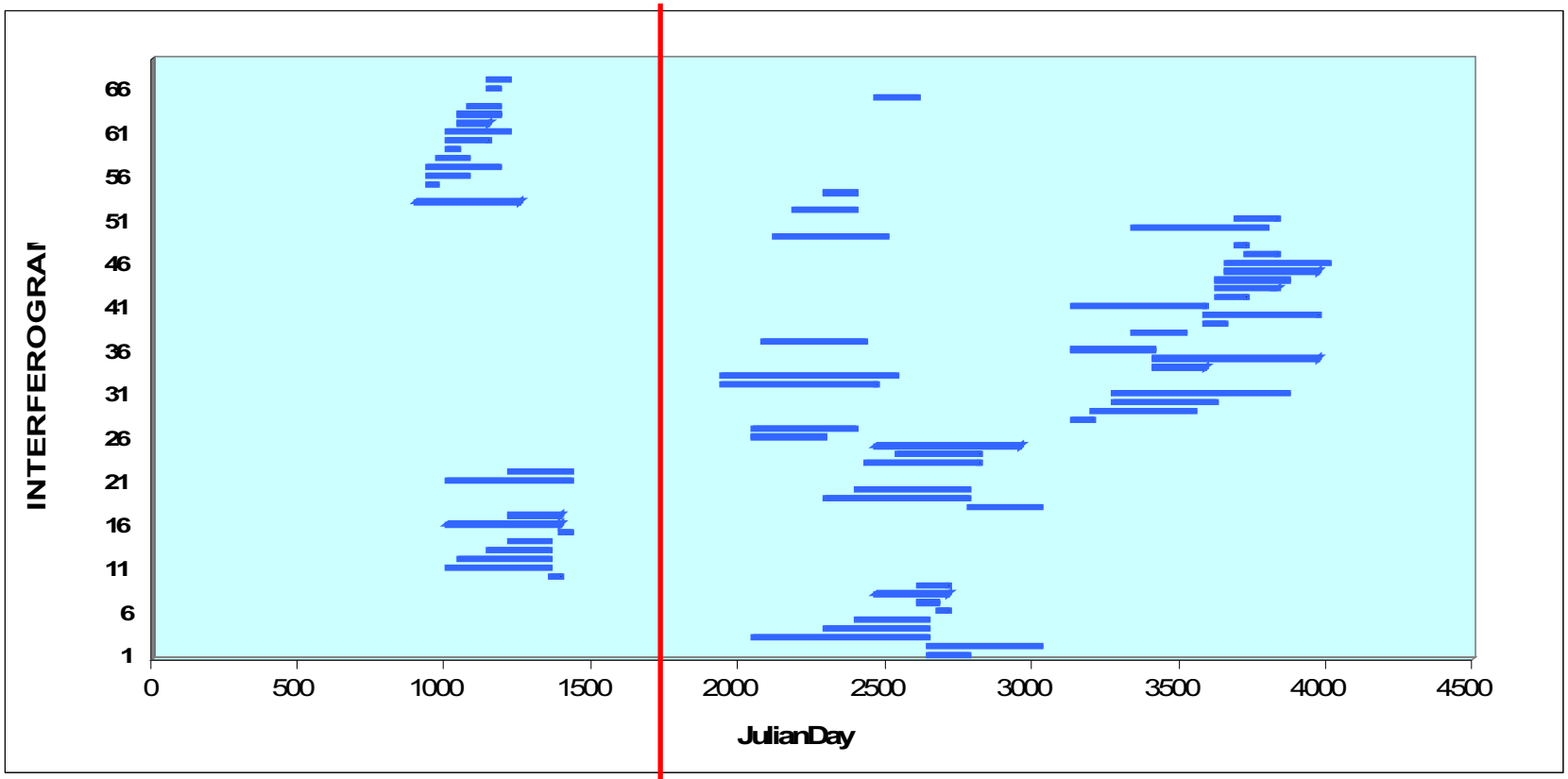
Test area in V2 SISMA Project

Gemona test area

Colfiorito test area

Pollino test area

Pollino test area (ERS1/2 images)



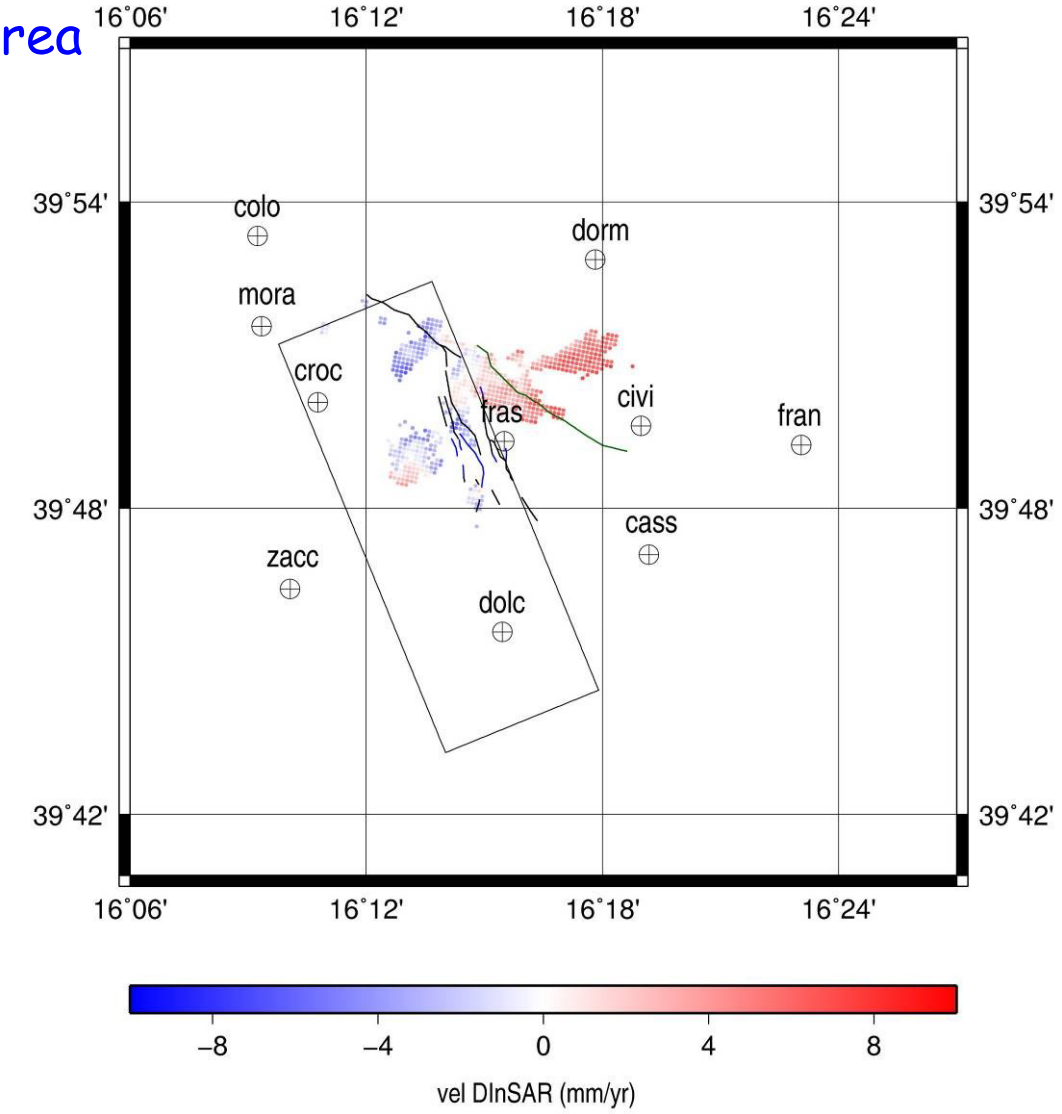
May 1992 – November 1993

April 1995 – Dicember 2000

Temporal interval:

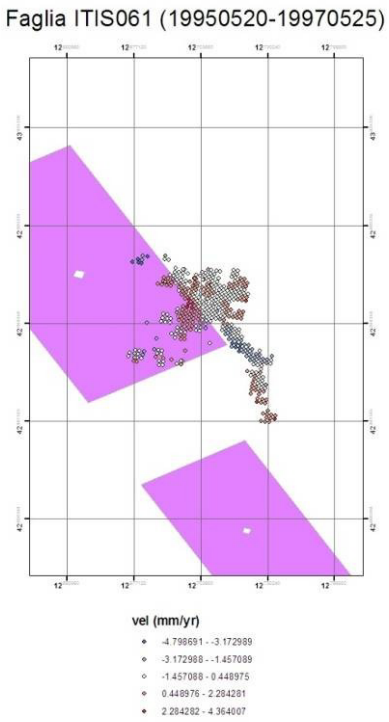
- 19920517 – 19931128: 18 interferograms and 11 images
- 19950425- 20001220: 51 interferograms and 38 images

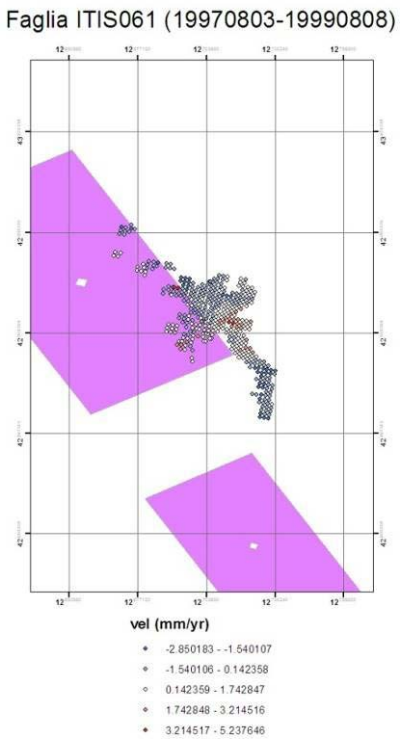
Pollino test area



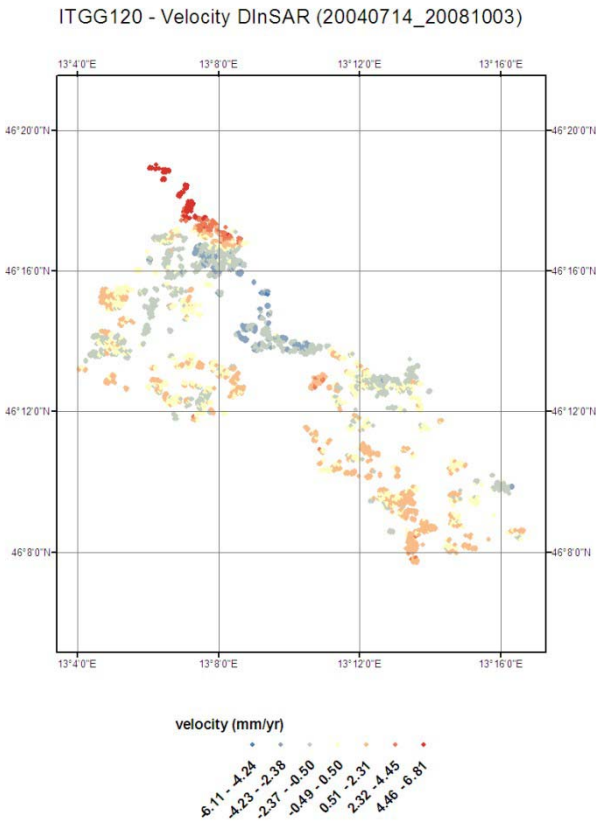
Velocity maps of Colfiorito fault (ENVISAT SAR IMAGE)

Production of maps of velocity considering two different time intervals



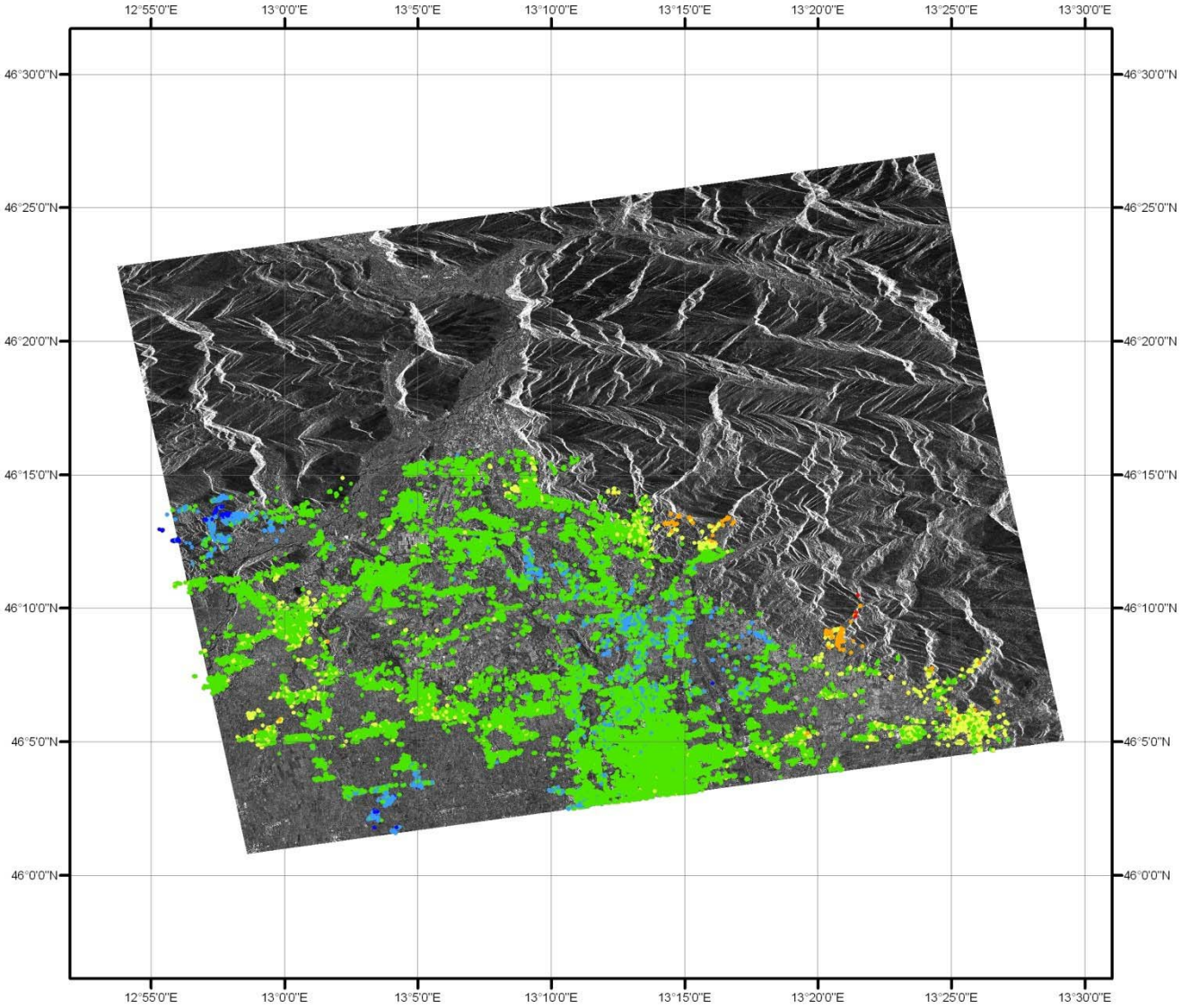


Analysis of the South Gemona area



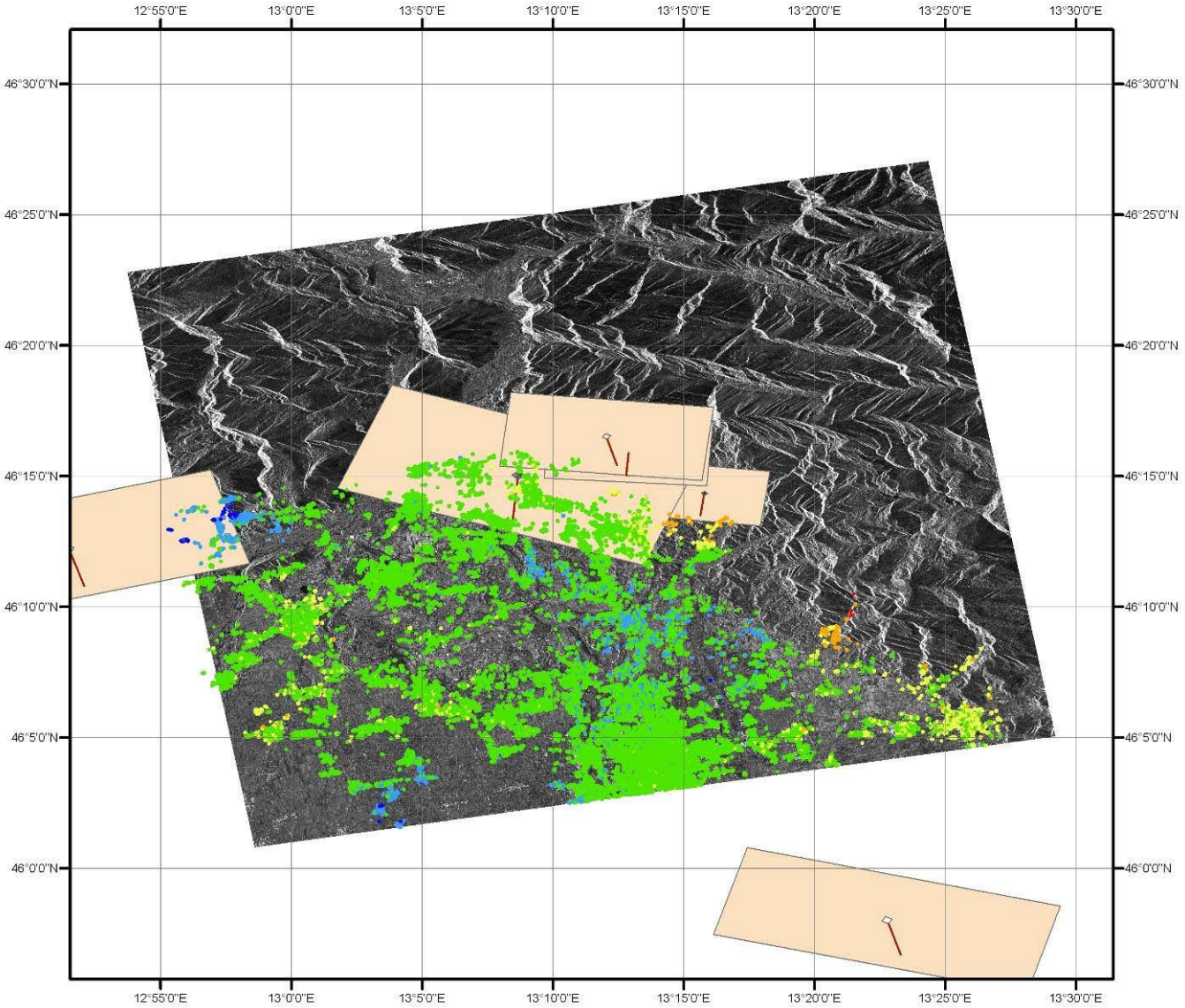
Within this study, the results were analyzed in relation to geological and hydrogeological situation of the area thanks to the retrieval of external data

B. Crippa, L. Calcagni, G. Rossi, and P. Sternai (2009). Advanced Differential Radar Interferometry (A-DInSAR) as integrative tool for a structural geological analysis. European Geosciences Union General Assembly, Vienna 19-24 April 2009



Friuli (Gemona) test area using CSKMED images

N. Images 7
N. Interferogram 17
Interval 17/08/08-23/10/09



Friuli (Gemona) test area using CSKMED images

Legend

velocity-and-displacement.csv Events

velocity_in_mm_per_yr

- -22 - -20
- -20 - -10
- -10 - -5
- -5 - 5
- 5 - 10
- 10 - 20

Conclusion

The management complexity of the DINSAR + VELLIN procedures requires an operator with a good knowledge of the interferometric techniques.

The vaste volume of the SAR data (1 image = 0.5-1.4 GigaByte!) is a component which imnpacts on computation time.

The procedures needs manual operations (SAR operator) and of the externals information.