

***Multi-source remote sensing  
integration:  
VHR SAR and Optical data for extraction  
of agro-environmental parameters***

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**from Italian presentation in Madrid  
November 2007...**

AGEA, in 2007 used its airborne multisensor system Tealer, in agreement with JRC, for testing **SAR band X** (and Hyperspectral) in agro-environment applications, with the same CwRS approach...

Data was exchanged with JRC

The results have been helping to investigate the potential usability of such a system (high resolution SAR band X) particularly for monitoring

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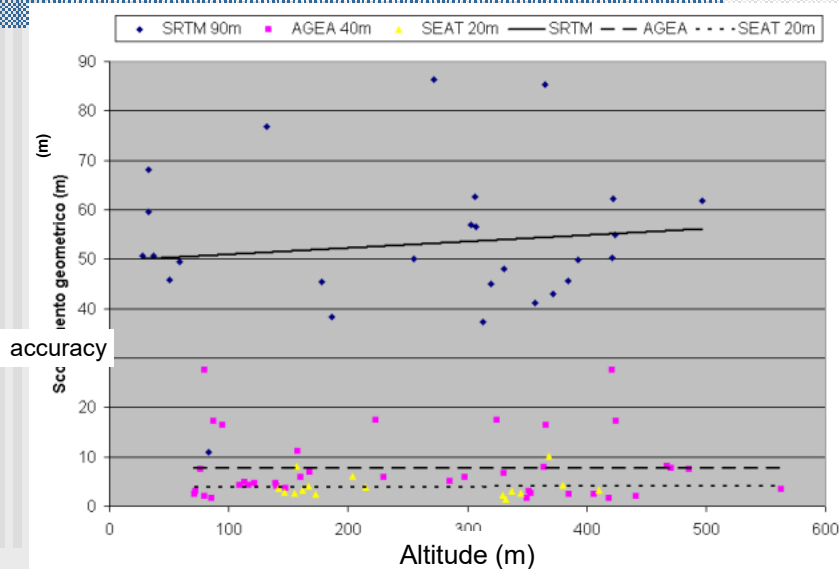


## Main results using Telaer SAR airborne band X

- ④ For land use identification good relationship between crop groups with the same geometry (through geometric identification)
- ④ For eligibility detection, good for excluding almost all ineligible land uses
- ④ For Cross-Compliance good mean for some GAEC agro-environmental parameters, through the acquisition capability (year-round, all-weather, false 3D)
- ④ For ortho-rectification processing, evident issues appeared in spatial accuracy achievements

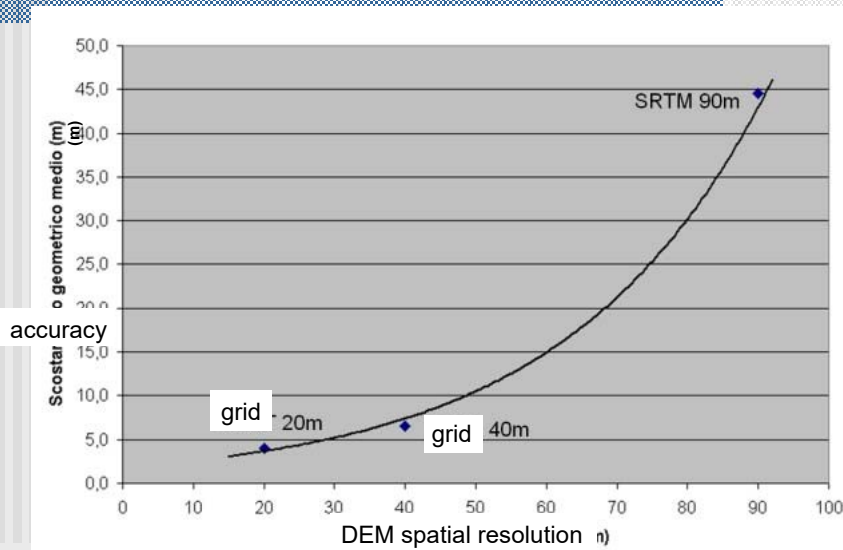
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Orthorectification: Geometric accuracy (Y) relating to altitude (X) using different DEM. The altitude (in non complex morphology) does not affect the accuracy level, while DEM impact seems to give a strong dependance

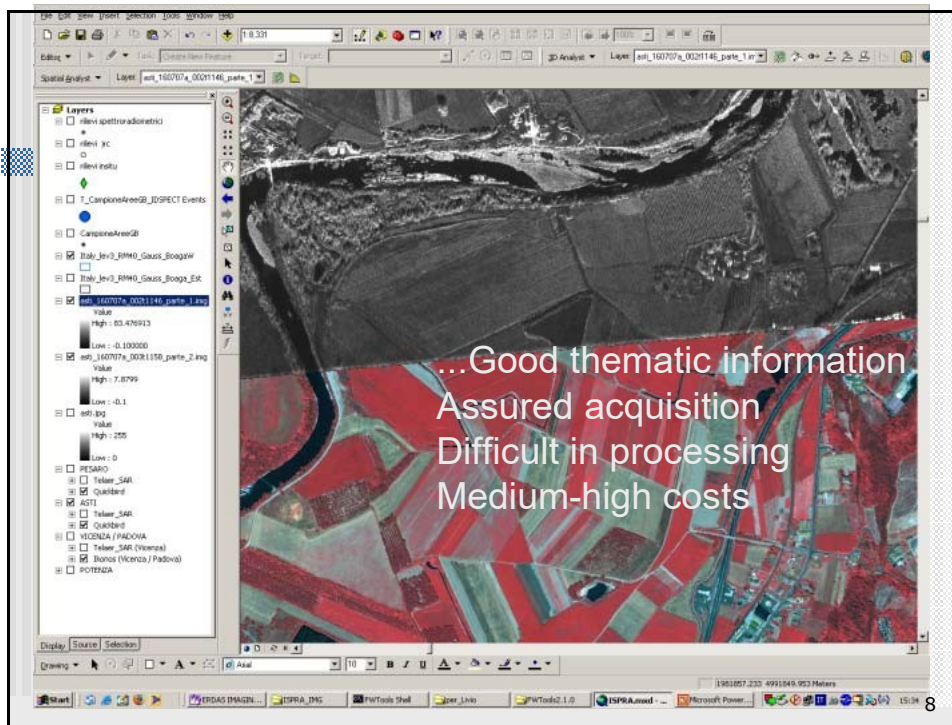


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Mean values according to different DEM used. With 20m grid the achievement is around 4 m, but the curve shows better possible achievable results



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## From 2007: Next steps and future scenarios

- ④ ...New Telaer experiments will be carried out, especially given the strong synergy with the new VHR SAR satellites, especially **Cosmo Skymed** from ASI (Italian Space Agency)

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## Cosmo constellation – 4 satellites



Cosmo 1 launch, June 8, 2007



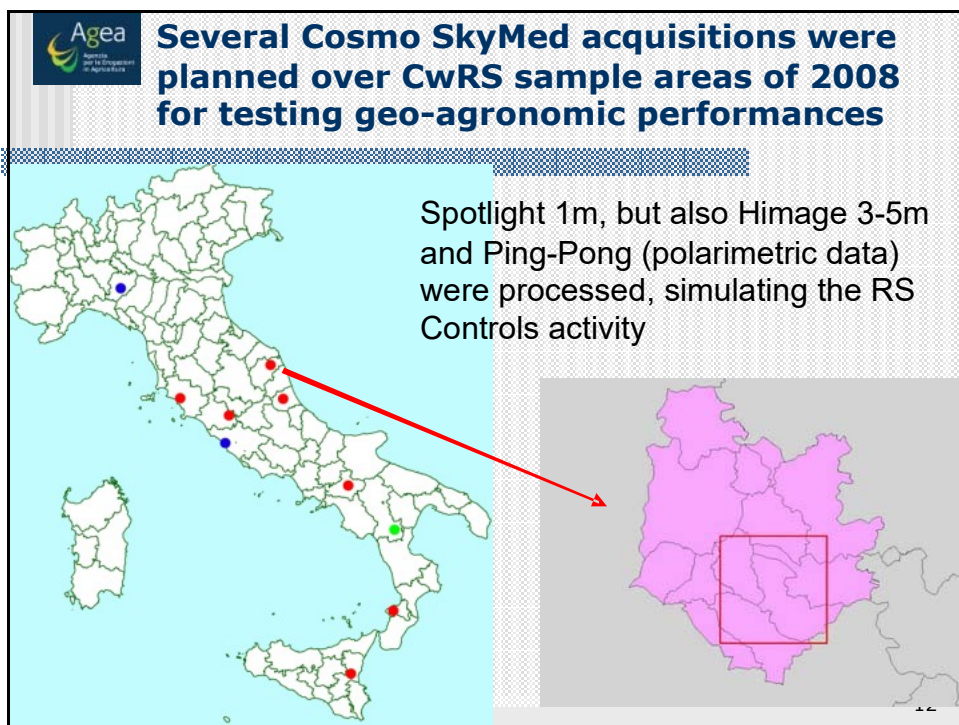
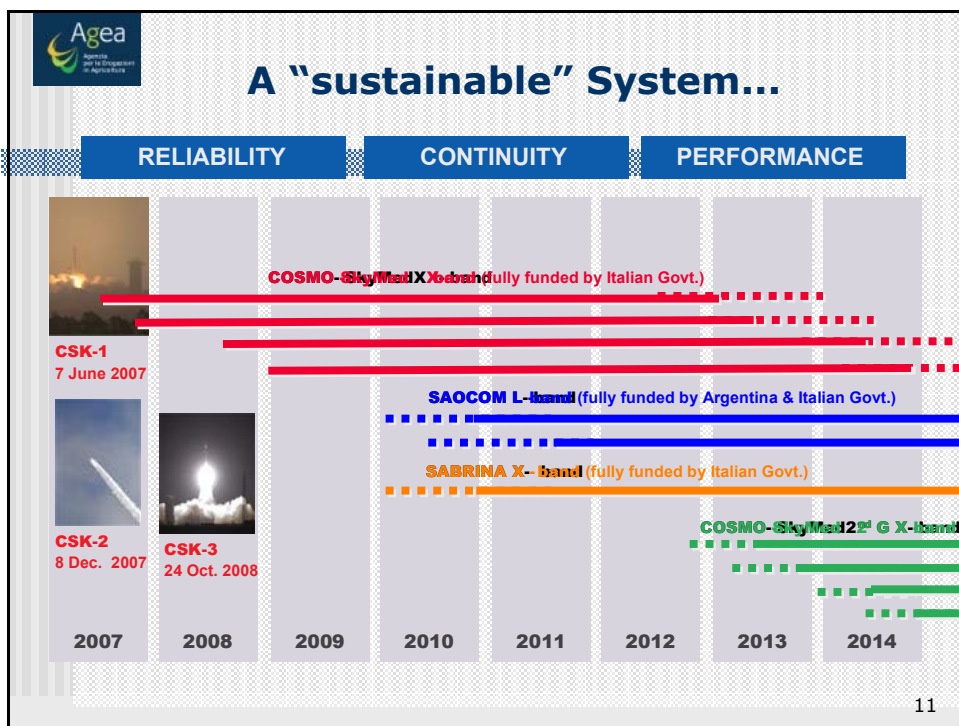
Cosmo 2 launch,  
Dec. 9, 2007



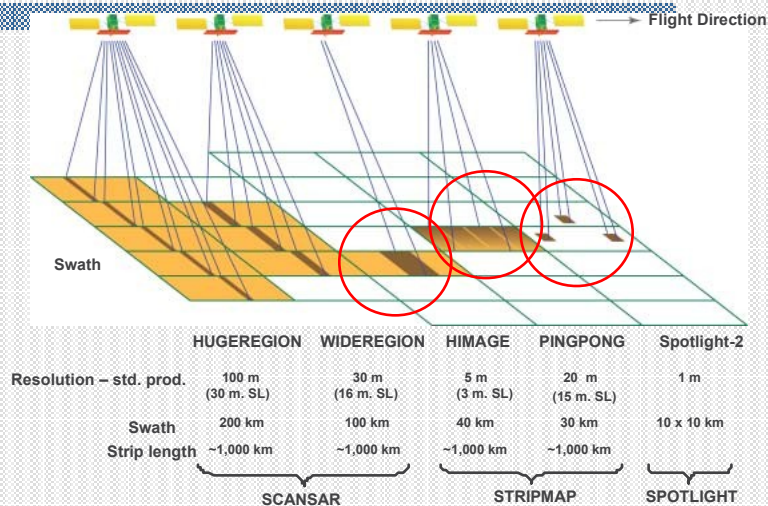
Cosmo 3 launch, Oct. 24, 2008

....Cosmo 4, year 2009

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## Multiple imaging modes



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## COSMO-SKYMED Geocoding (1)

1. Original format data ingestion
  - SLC Image matrix in slant-range/azimuth geometry extraction
  - Acquisition of information retrieval:
    - 9 Satellite State Vectors (positions and velocities measured during acquisition)
    - 9 Sensor Mode (Spotlight1/2, Himage, Ping-Pong...)
    - 9 Acquisition characteristics (Looking direction, Passing mode, Angle of view)
    - 9 Scene centre e corners coordinates
2. Digital Elevation/Surface Model extraction
3. Image Geocoding using "SARSCAPE" from Sarmap and Telaer proprietary software
4. Geo-coded Data filtering
  - Multi-look & Gamma Filtering for Speckle reduction
  - Amplitude image extraction

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## Geometric accuracy Assessment (1)

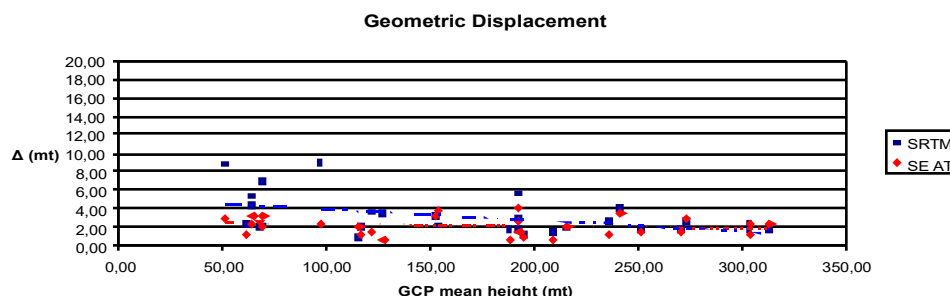
- ④ Evaluation tests on DEM quality impact upon SAR geometric accuracy were performed
- ④ Digital Models used:
  - DEM by SRTM 90m, freely available,
  - DSM from stereo optic pairs 20 m grid and declared accuracy of 5 mt.
  - Intermap 1m DEM interferometric flight: trial is on going...
- ④ Assessment method used:
  - 1) control points, both on SAR and on correspondent optical ortho-imagery used as ground truth
  - 2) coordinates of points, measured on COSMO-SKYMED (xs,ys) and on ortho-imagery (x0,y0). The absolute distance between these two measurements (geometric mismatch or accuracy determined by:

$$\text{Geometric mismatch} = [(x_0 - x_s)^2 + (y_0 - y_s)^2]^{1/2}$$

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## Geometric Accuracy Assessment (2)

- Preliminary results of accuracy assessment. In particular, mismatch measured are the average of GCPs taken on Cosmo Spotlight images acquired on Grosseto (flat-hilly) and Macerata (hilly) areas.



### Mean Geometric Mismatch Measured on agriculture areas

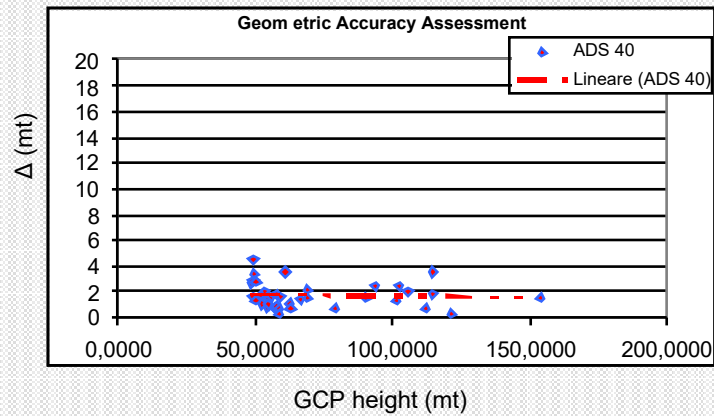
- SRTM : 3.06 mt
- 20mgrid: 2.05 mt (improvement ≈ 30%)

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## High Resolution DEM

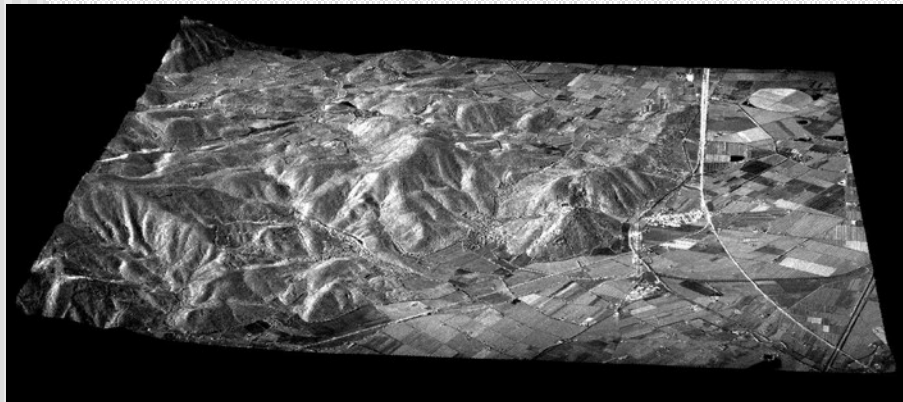
- ④ Test Mausanne, with high resolution ADS-40 Digital Terrain Model by JRC, with 2 m of grid and 2 m of accuracy



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## Example of Parcel measures (1)

Test Area: Grosseto



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## Example of Parcel measures (2)

IKONOS

Perimeter: 1782.71 mt

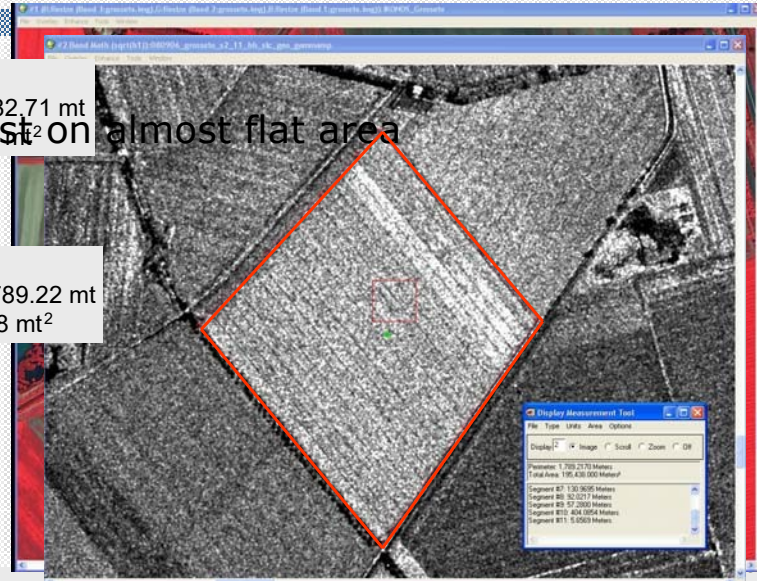
Area: 193750 mt<sup>2</sup>

Test on almost flat area

CSK

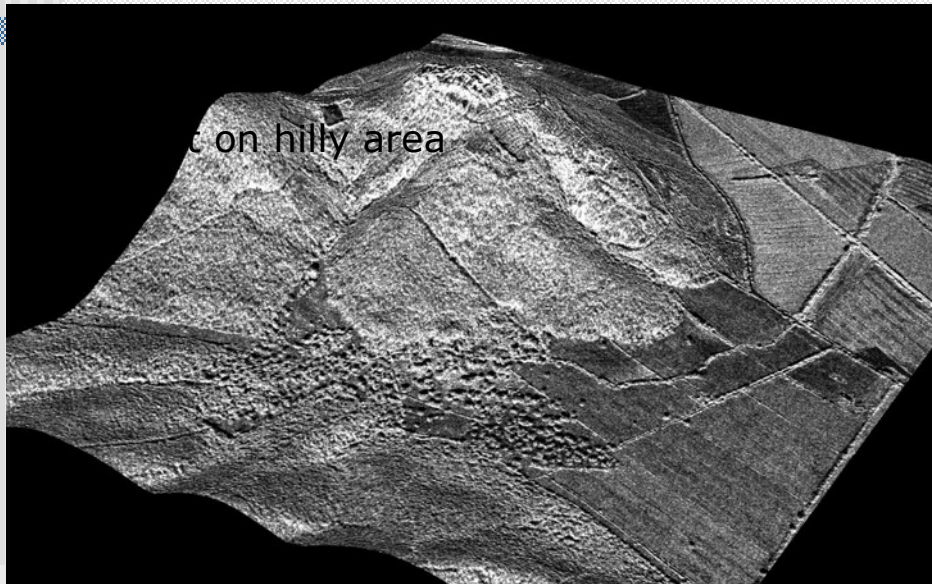
Perimeter: 1789.22 mt

Area: 193438 mt<sup>2</sup>



## Example of Parcel measures (3)

Test on hilly area



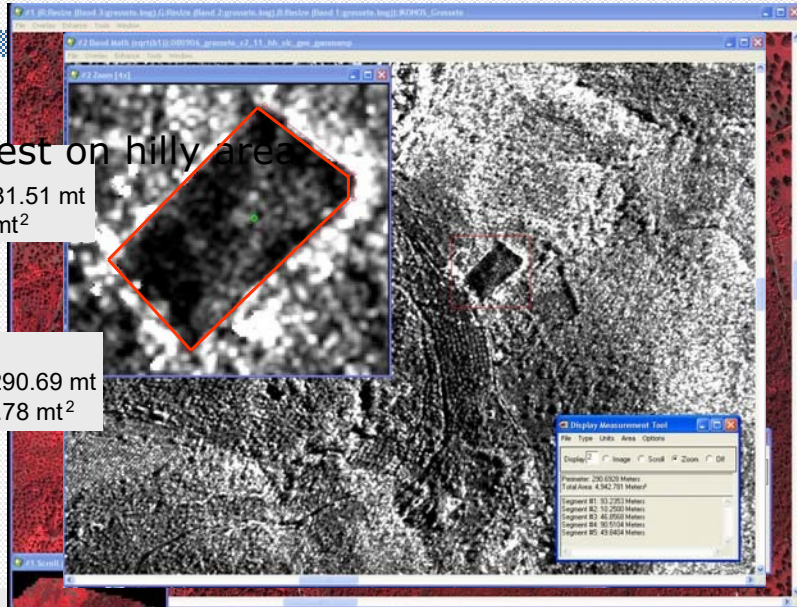
## Example of Parcel measures (4)

IKONOS Test on hilly area

Perimeter: 281.51 mt  
Area: 4783 mt<sup>2</sup>

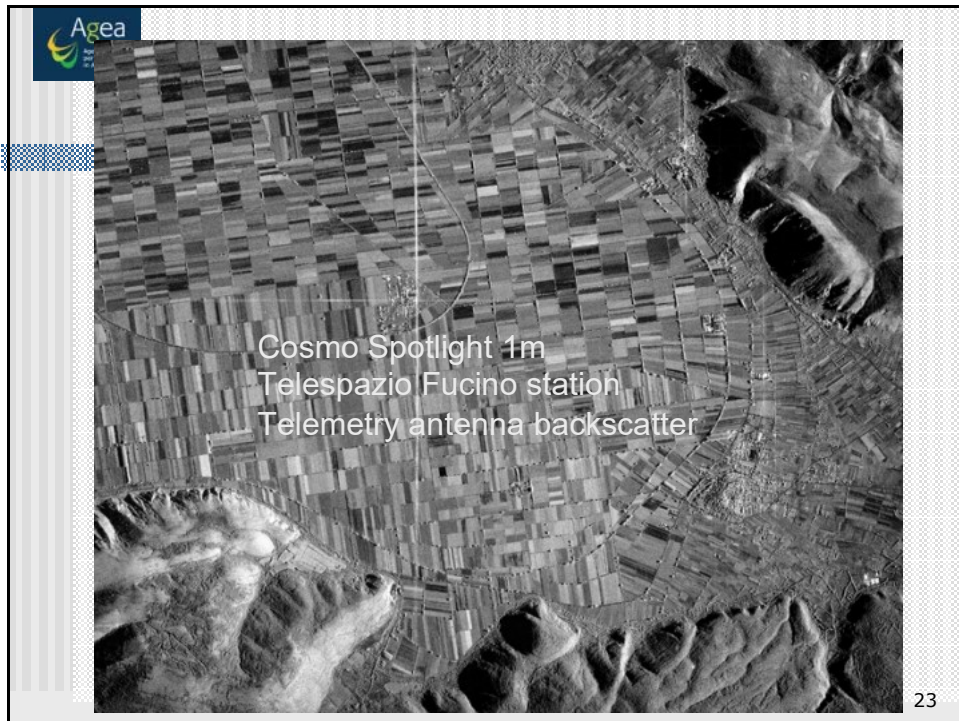
CSK

Perimeter: 290.69 mt  
Area: 4942.78 mt<sup>2</sup>



## Examples of preliminary results

		I konos	CSK-Spotlight	Del ta
Almost flat area	P erimeter	1782.7	1789.2	0.4%
	A rea	193773.0	195438.0	0.9%
Hilly area	P erimeter	281.5	290.7	3.3%
	A rea	4783.0	4942.8	3.3%



Agea

## Cosmo Skymed SAR X

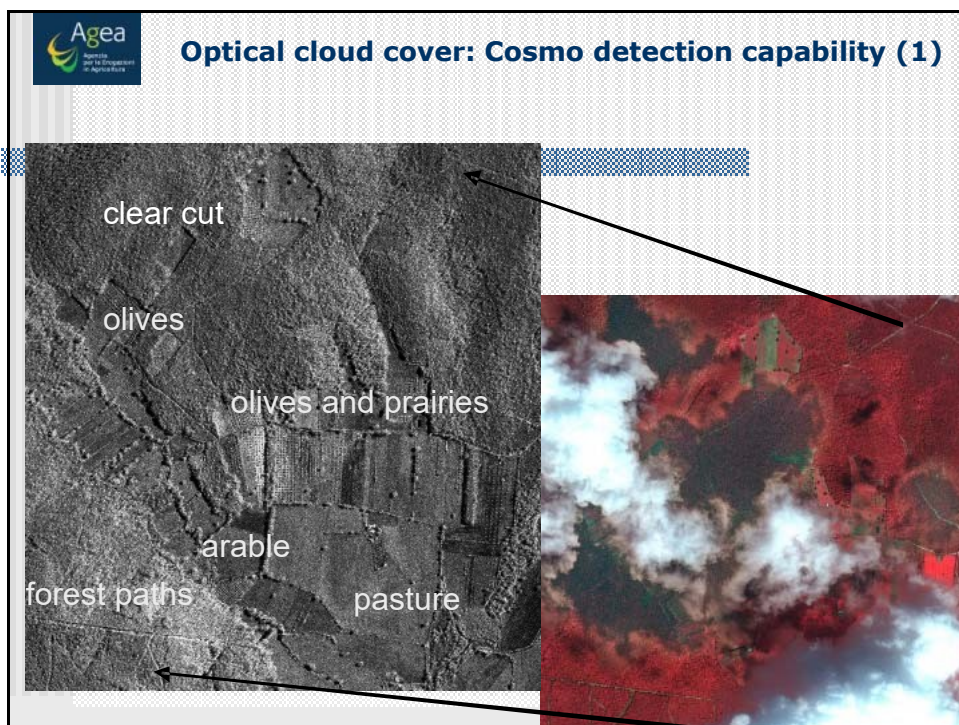
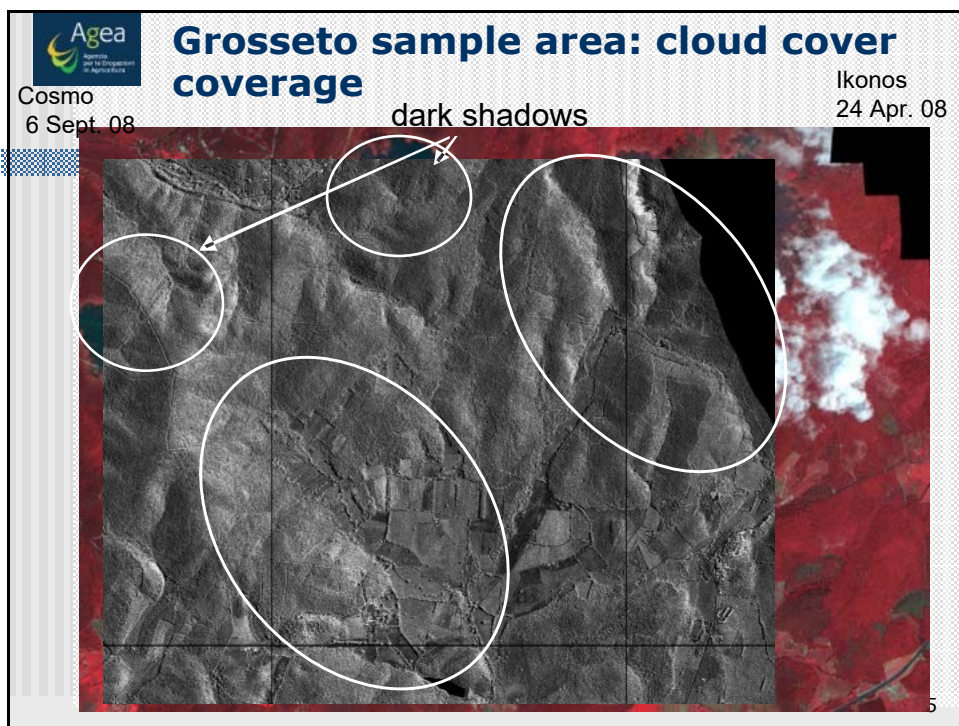
### Land use capability

- ④ Cloud cover presence in optical data (also if in JRC tolerance? Lack of optical acquisition for persistence of cloud?)
- ④ Crop groups detection?
- ④ Multi-temporal feasibility?

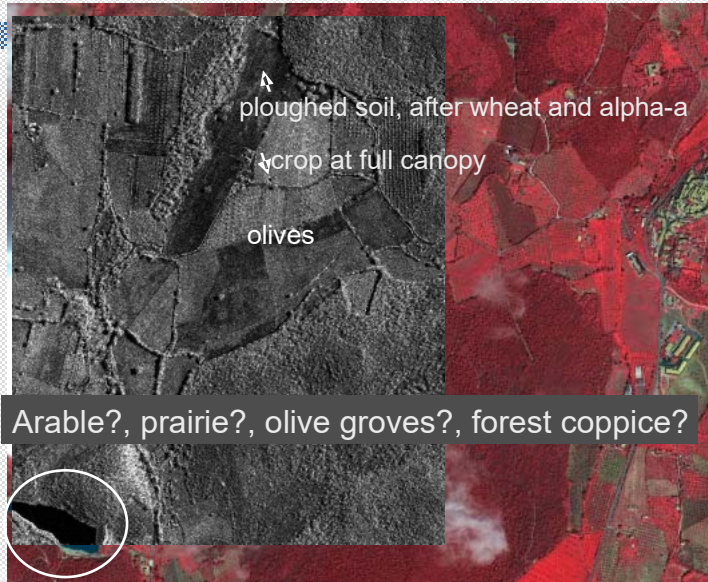
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This slide has a light gray grid background. It features the 'Agea' logo in the top left corner. The title 'Cosmo Skymed SAR X' is centered at the top in a bold, dark blue font. Below the title is a horizontal blue patterned bar. The main heading 'Land use capability' is centered in a large black font. Below this, there is a list of three questions, each preceded by a red circle containing a white number '4'. The slide number '24' is located in the bottom right corner.





## Optical cloud cover: Cosmo detection capability (2)

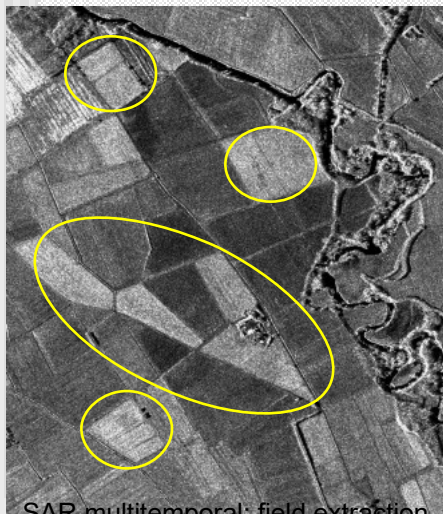


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## Cosmo: Multitemporal agronomic land use capacity

Cosmo 30 Sept. 08

Optical 4 Jul. 08



SAR multitemporal: field extraction



summer crops among rice fields<sup>28</sup>



## L'Aquila Central Italy: intensive vegetable rotational crops

Ikonos, 6 July 08

Cosmo 3 Sept. 08

late  
summer  
vegetables

Hedgerow/trees  
detection and  
monitoring

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## Grosseto, tree counting (small olives)

Ikonos  
24 Apr. 08

Cosmo 6 Sept. 08

...It is necessary to know  
in advance the "local"  
tree-row spacing and the  
permanent cultivation  
tradition

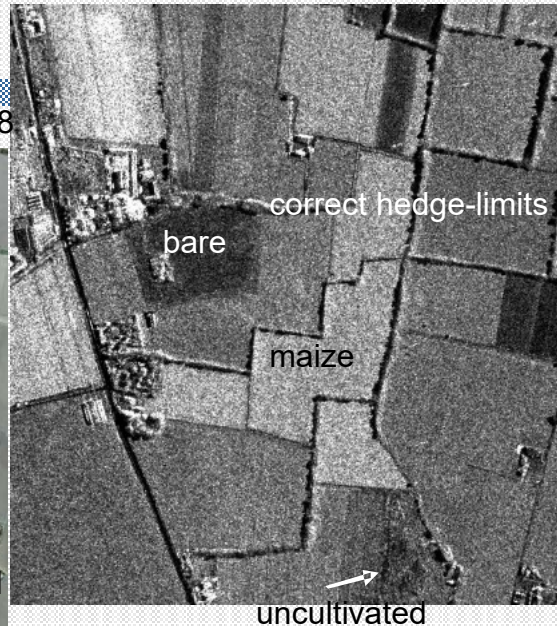
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## Piacenza, Padana plain-crop/ineligibility detection

Cosmo 6 Sept. 08

Airborne 40 cm, August 08



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## Grosseto, Multi-temporal crop analysis by Cosmo

Ikonos 7 July 08

Cosmo, 30 Sept. 08



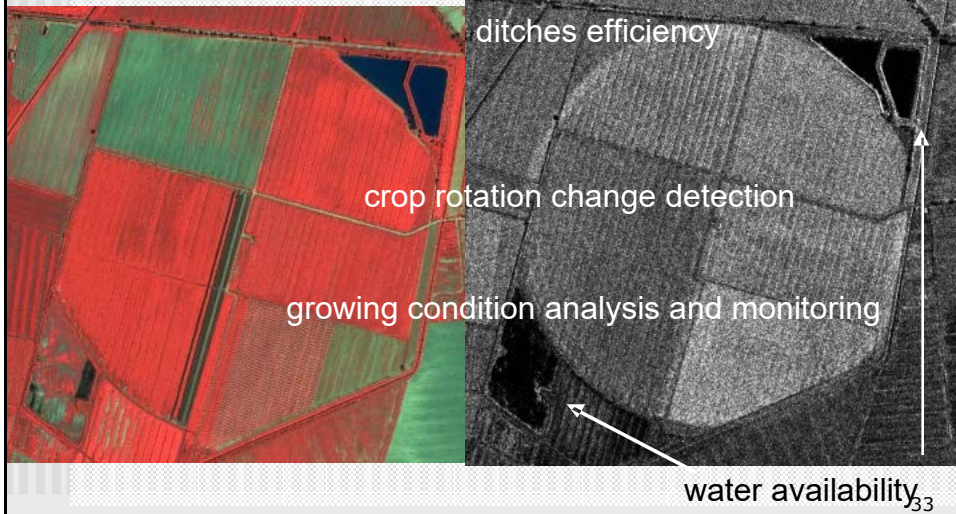
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## Grosseto- irrigation structures monitoring (pivot)

23 Apr. 08

6 Sept. 08

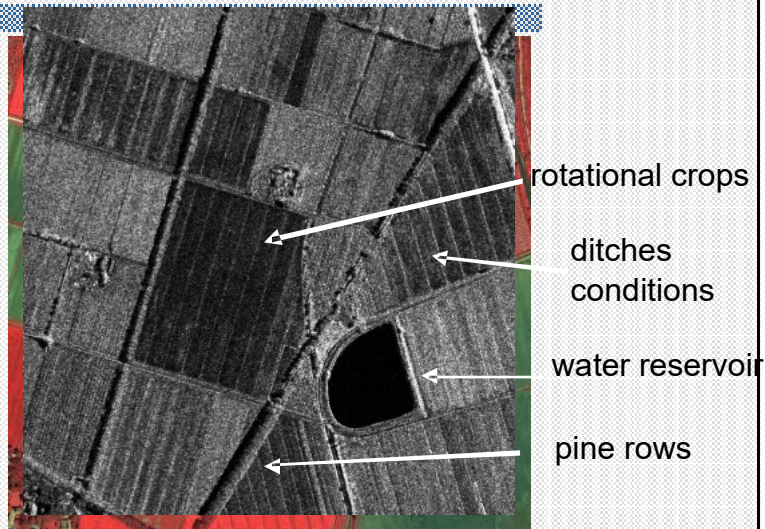


## Central Italy: reclaimed land monitoring

grass coverage monitoring

Optical  
23 Apr. 08

Cosmo  
6 Sept. 08



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## Cosmo Skymed SAR X

### Capability in parcels eligibility/updating

- ④ Non eligible areas detection: built-up, woodland and transitional, transportation, road network,...
- ④ LPIS periodical updating, also when cloud cover is persistence

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## L'Aquila Central Italy: vegetable rotational crops, pastures, ineligible zones..

Ikonos, 6 July 08

Cosmo, 3 Sept.08

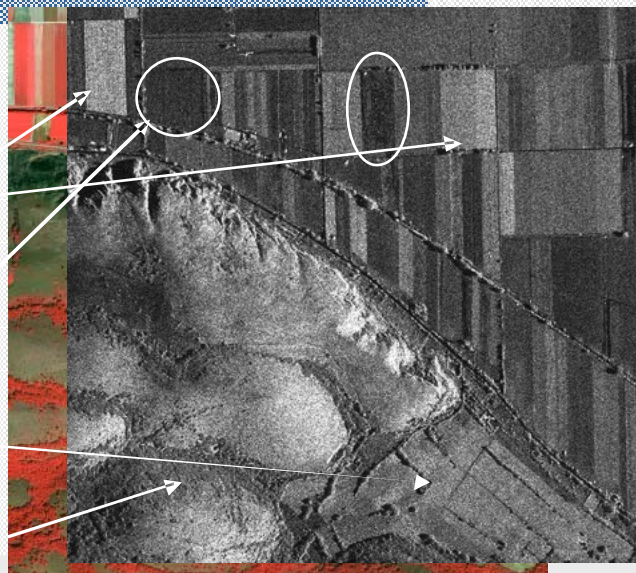
late summer  
vegetables

harvested fields

bare soil maintained

permanent pastures

rocks and transitional  
> reforestation



## Pavia agro-environmental analysis

Ikonos 4 July

Expansion pond

Paddy structures

Wet zone:  
former meander

Quarry- quarry lake

Poplar grove

Cosmo  
30 Sept.

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## Cosmo: Agro-environmental parameters (2)

4 July 08

Paddies

Wetland and ponds

Poplar plantations

Mixed natural woodland  
30 Sept.08

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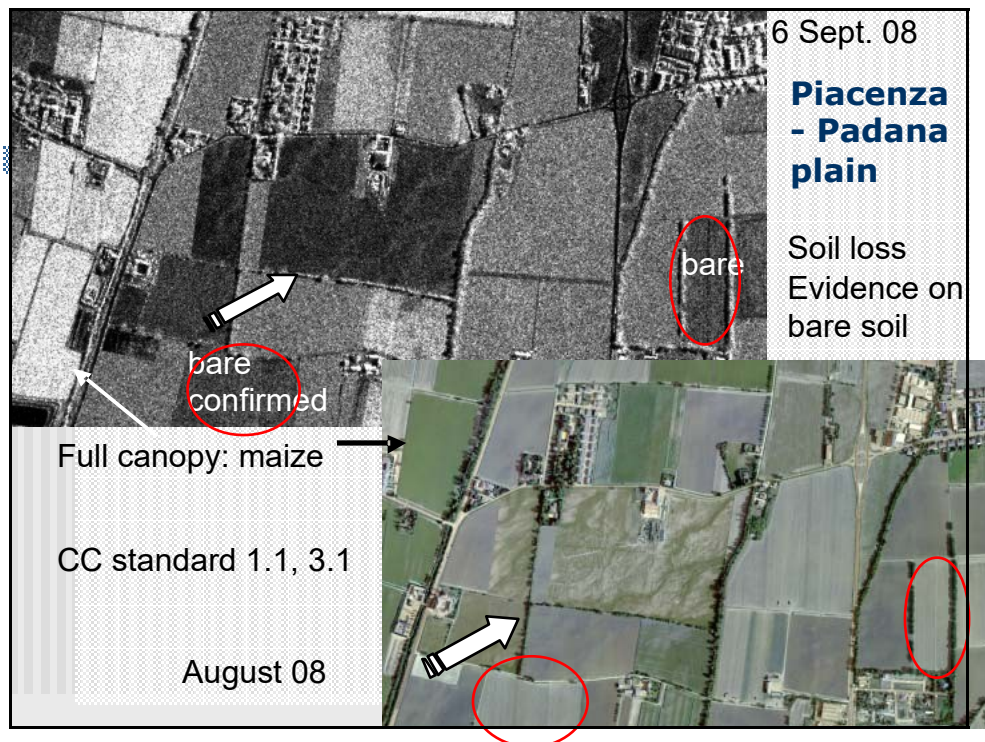


## Cosmo Skymed SAR X

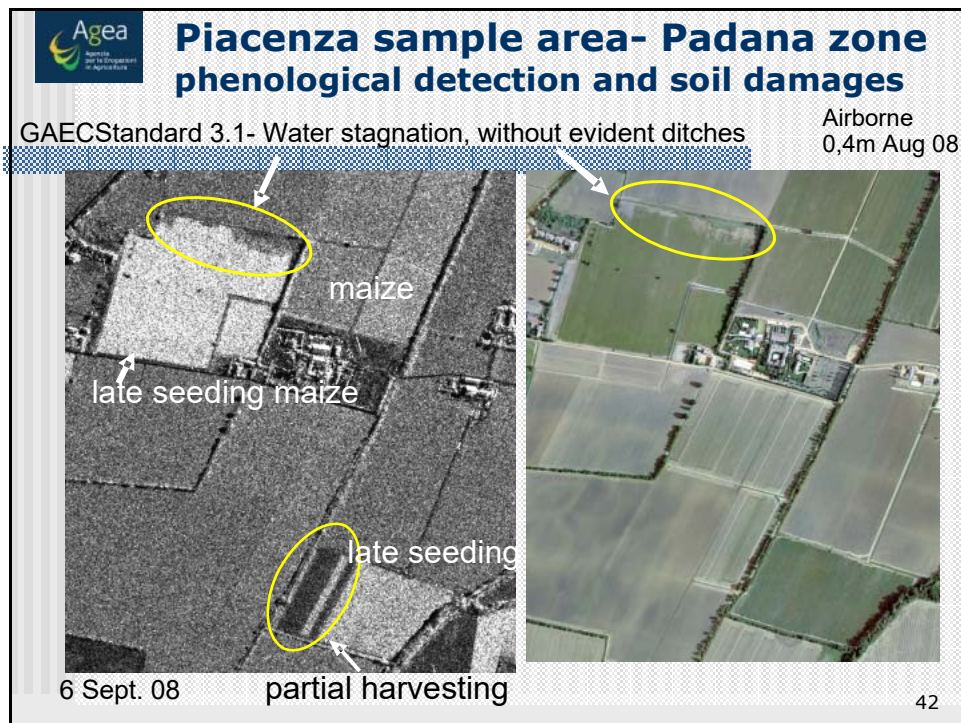
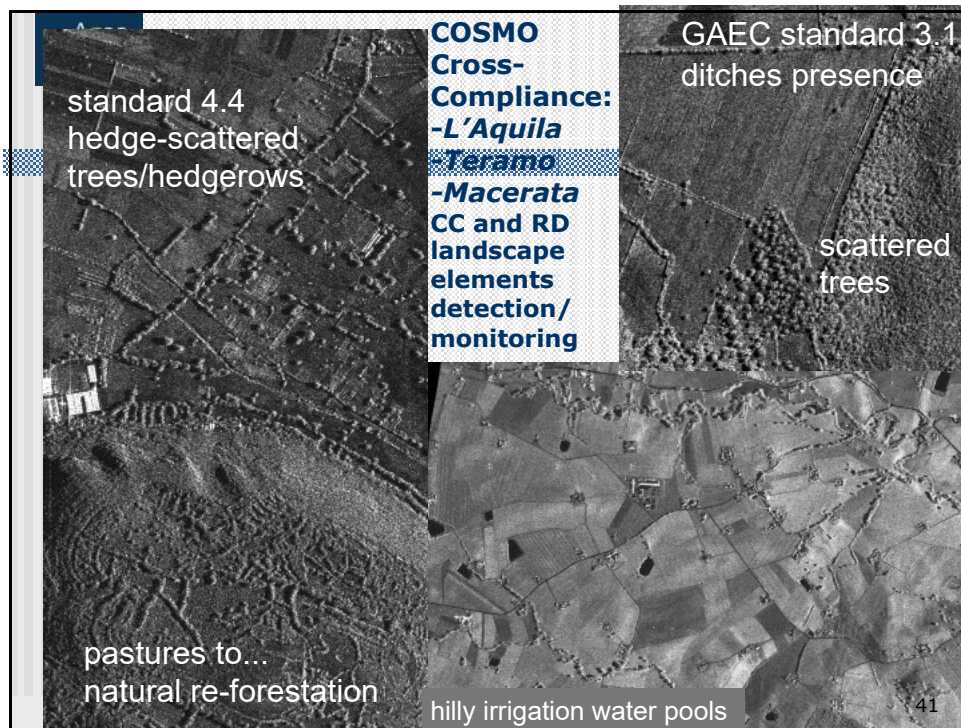
### Cross-Compliance and Rural Development: information source

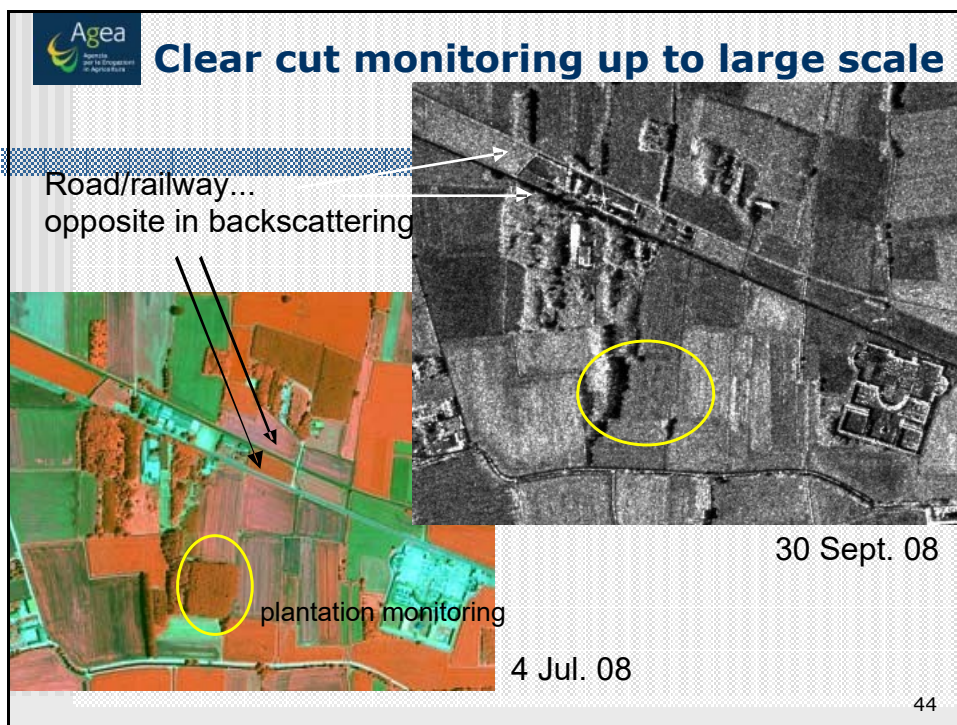
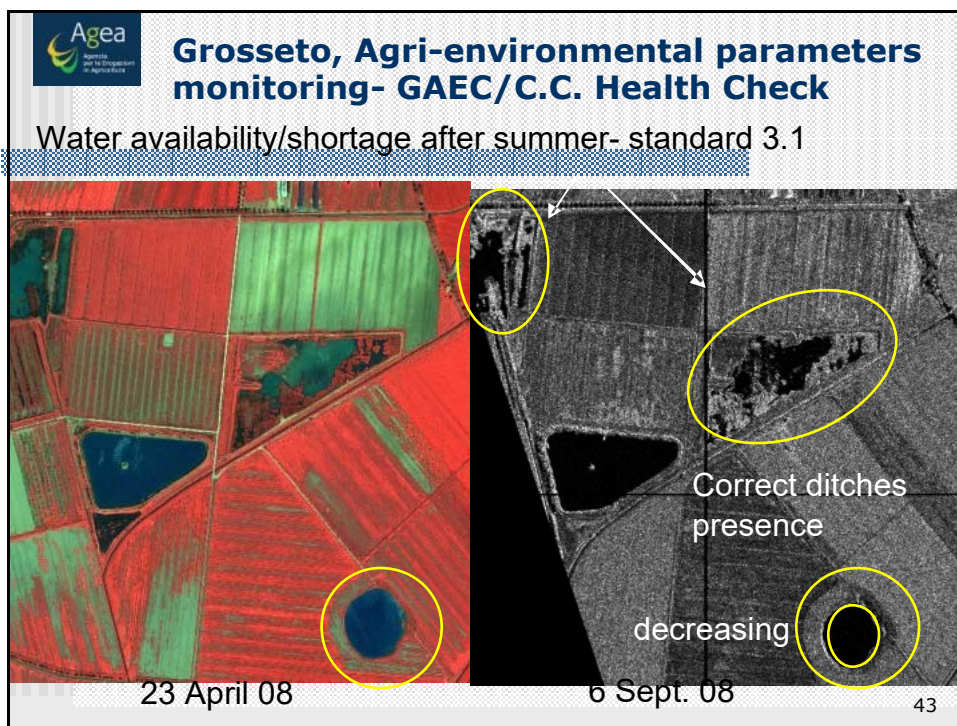
- ④ GAEC standard parameters, detection and infringements
- ④ Rural Development elements, detection and monitoring

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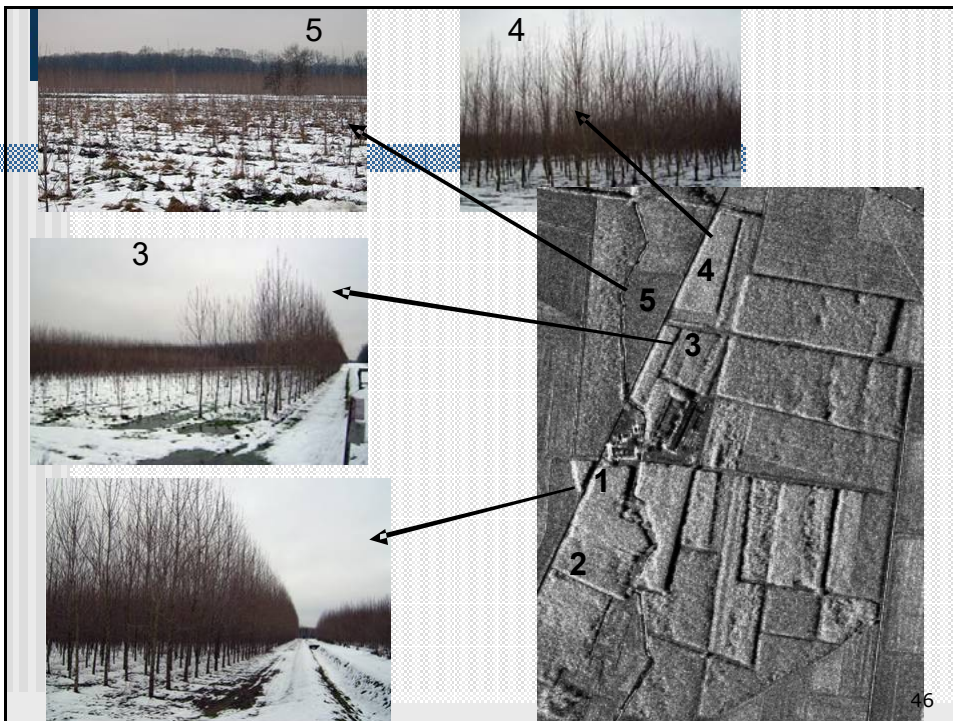
**Cosmo spotlight:**  
**Woodland typologies**  
**detection capability**  
**North Italy**



**Poplar groves at different density and age:**  
**experimental timber farm (biomass production test)**



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## Interferometric Land Use and Multi-temporal Synthesis

Interferometric couple of SAR Cosmo Spotlight Band X.  
Multi-temporal RGB synthesis, using coherence imagery

Pavia 2007 sample area:

Two interferometric mode acquisitions

Date : 30 September and 9 November 2008

Acquisition direction : Right

Passing mode : Ascending

Polarization : Horizontal HH

Observation angle :  $35.67^\circ$

Satellites used : CSK1 in September and CSK2 in November

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## SAR amplitude: Pavia 2008, September 30th



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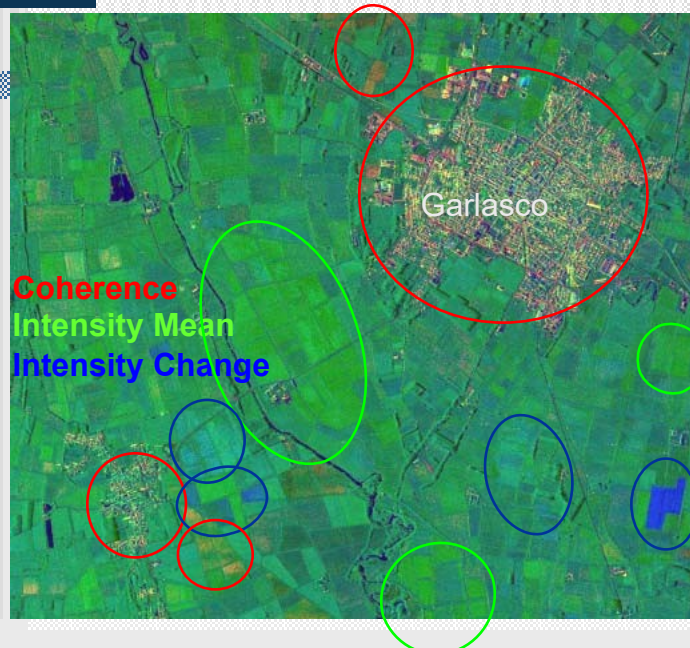


## SAR amplitude: Pavia 2008, November 9th



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## Interferometric Land Use (ILU)

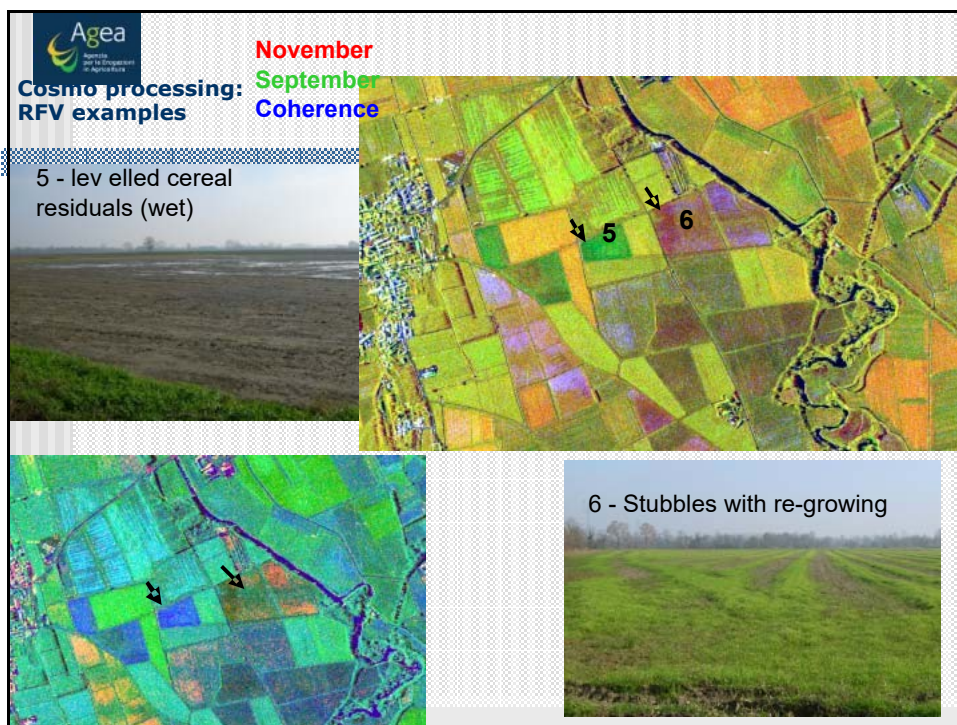
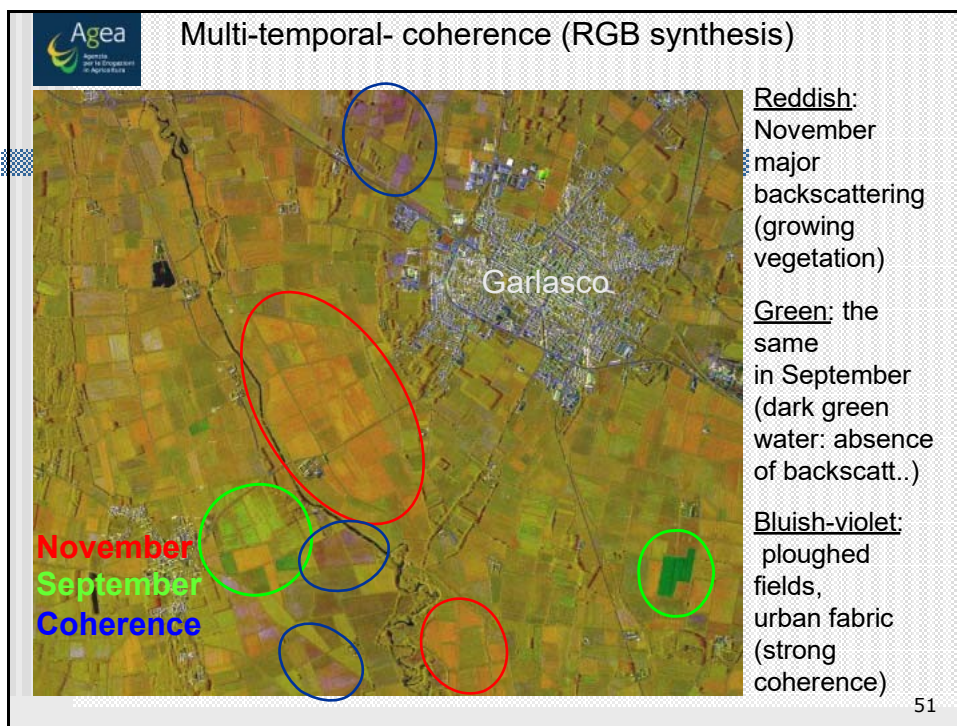


Reddish: built-up areas, infrastructures, no vegetation (stubbles, ploughed)

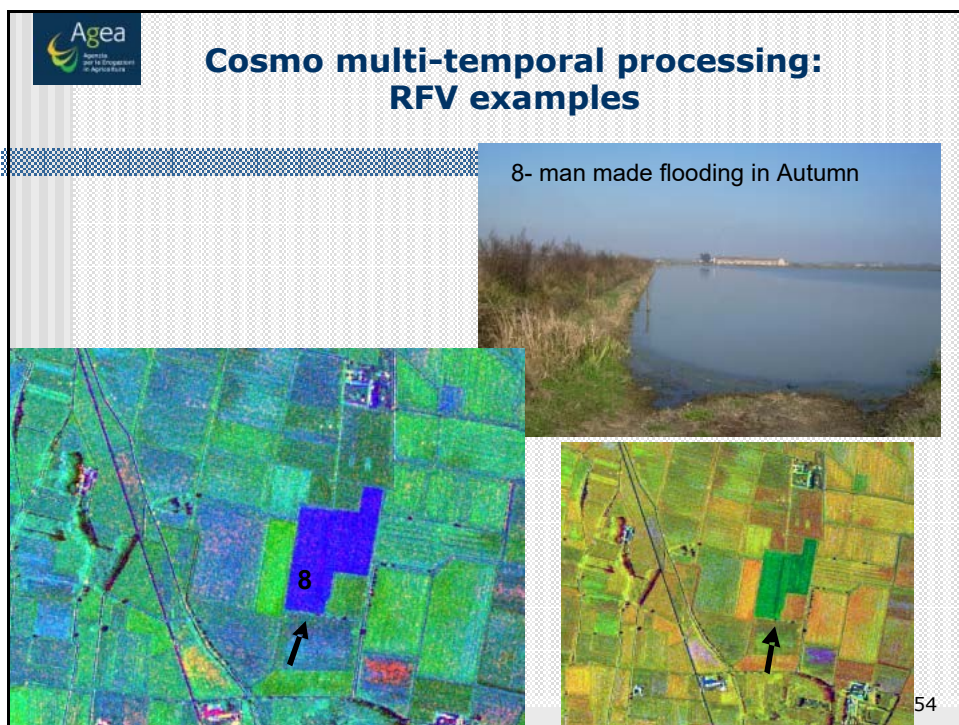
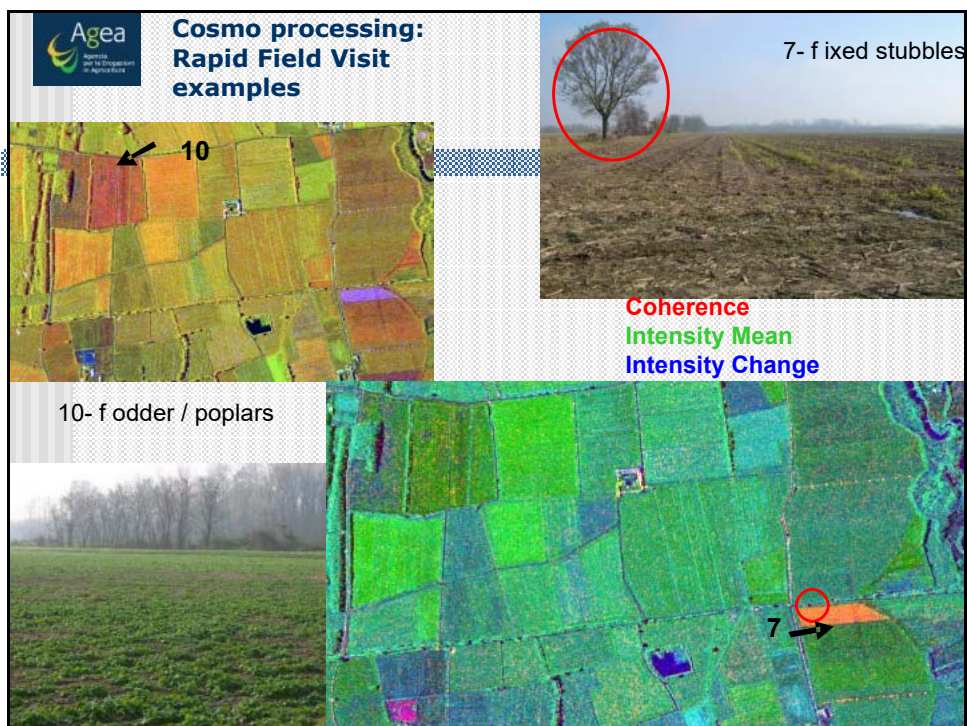
Green: vegetation variability and growing difference levels

Bluish: change in water presence and in wet areas (digital levels)

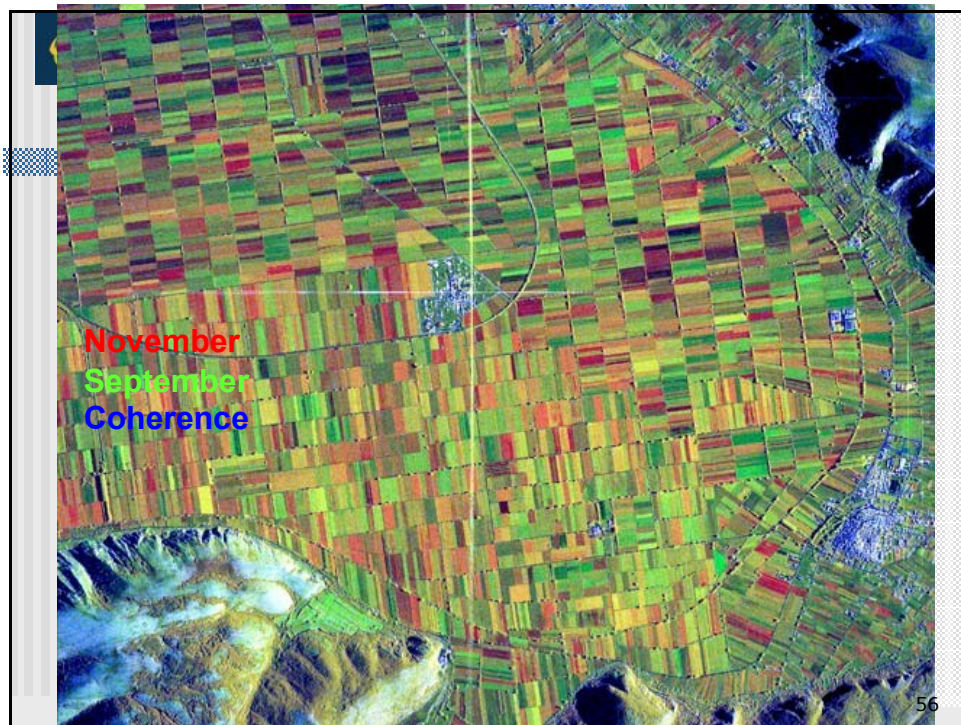
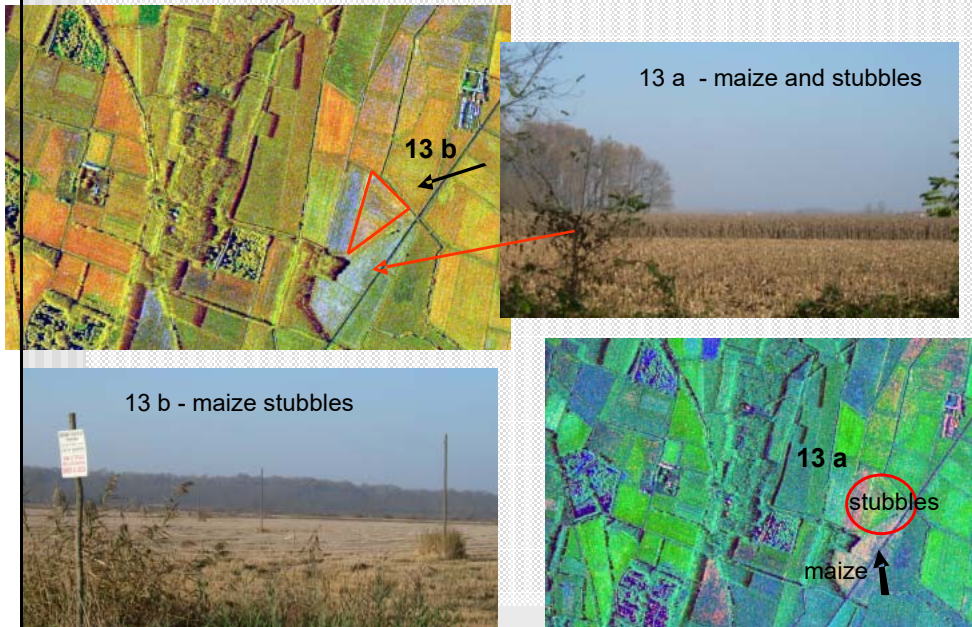
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## Cosmo processing: Rapid Field Visit examples

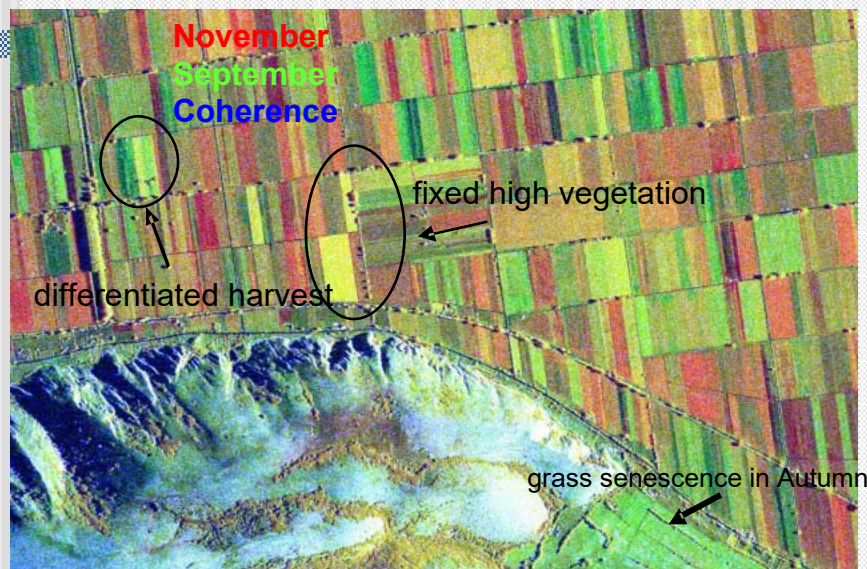




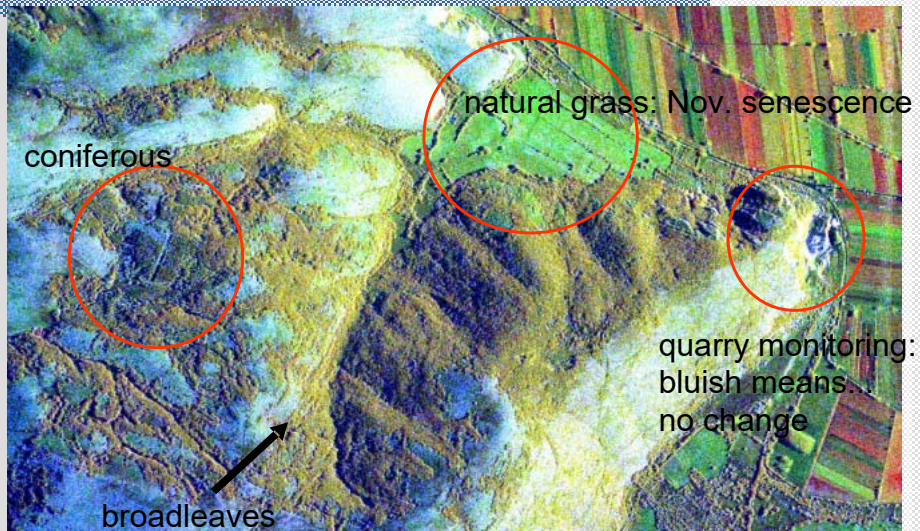
## L'Aquila- central Italy: agronomic pattern



## L'Aquila- central Italy: agronomic pattern



## L'Aquila- central Italy: different agronomic patterns; quarry monitoring...



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**Coherence**  
**Intensity Mean**  
**Intensity Change** ILU

Without coherence, illegal activities can be immediately detected...  
New buildings, quarry enlargements, logging etc..



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## On going activities...

Exploitation in using different Cosmo data (multiple sensors and different acquisition geometry) ILU and Color synthesis improvement

### Tasks - Development of techniques for:

- z SAR data Co-registration, based on feature extraction, using:
  - ④ SAR data with different acquisition geometries
  - ④ SAR and Optical images
- SAR Segmentation and multi-polarization usability (PingPong)

### Expected Results:

Tools/algorithms identification to improve the capability from different image sources aimed at:

- z speed up the processing and the photo-interpretation
- z increase the accuracy of geocoding
- z improve the automatic processes and verified "extractions"

## Conclusions/remarks (1)

### Geometrical issues

- ④ Cosmo satellite Spotlight shows good performances in flat areas (2-3 m); less in complex morphology, where left-right orientations could affect the geometric results (changing point of view of slope/parcels); satellite acquisition angles relating to the target sloping must be pre-selected
- ④ DEM accuracy does not influence too much the precision in ortho-rectification, such as for SAR airborne; 23° amplitude for airborne (the usual range is 22°-45°), while 2° for satellite (10km swath from 620 km)
- ④ Also when morphology (or resolution) does not permit to work within tolerance, SAR (both Spotlight 1m and Himage 3m) allows to confirm or not single parcel eligibility, postponing to RFV for doubt and parcelization (10-20% of total?)

## Conclusions/remarks (2)

### Thematic assessment

- ④ Agronomic land use: good performance, especially having optical reference data and working in multi-temporal; "coherence" advantage using band X
- ④ Eligibility updating: good performance, all macro-land use are detectable; less negative influence due to vegetation canopy enlarging than the SAR airborne
- ④ Cross- Compliance ad Rural Development measures: like airborne SAR X, good detection capability, better in case of multi-temporal analysis for: erosion, damages, water stagnation, traditional agronomic structures (terraces, stone walls, hedge-row/trees, grass coverage, pools, drainage systems, etc.) No for olives maintaining, sludge, burning stubbles..?)
- ④ Without forgetting.....

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**..assured data around the agronomic year, the illumination (day/night), the weather....**



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