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MULTITEMPORAL ANALYSIS

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Outline

1 Current trends and background on multitemporal images

2 Change detection in VHR multispectral images

3 Change detection in VHR SAR images

4 New challenges in multitemporal analysis

5 Discussion and Conclusion

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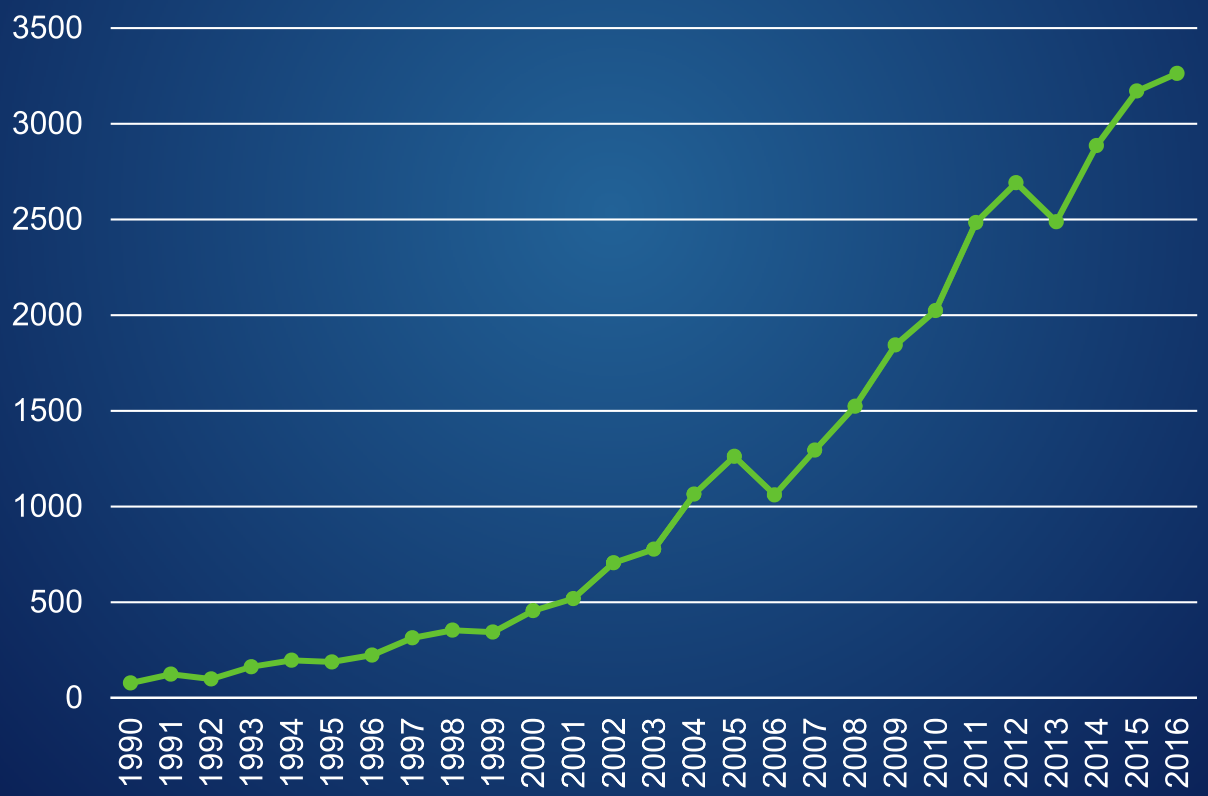
1. Current Trends and Background on Multitemporal Images

Introduction

Introduction: Multitemporal Analysis

Number of papers published in the major journals and conferences (source: Scopus) related to methodologies and applications of multitemporal analysis between 1990 and 2016



Introduction: Multitemporal Analysis

The increased interest in multitemporal data analysis is due to many issues:

- ✓ Increased number of satellites with increased revisit time that allow the acquisition of either long time series or frequent bitemporal images.
- ✓ New policy for data distribution of archive data that makes it possible a retrospective analysis on large scale (e.g. the Landsat Thematic Mapper archive).
- ✓ New policies for the distribution of new satellites data (e.g. ESA Sentinel, Landsat 8).

Multitemporal Images: Change Detection

- Change detection (CD): process that analyzes multitemporal remote sensing images acquired on the same geographical area for identifying changes occurred between the considered acquisition dates.

- We can define different change detection problems:
  - ✓ Binary change detection.
  - ✓ Multiclass change detection.
  - ✓ Change detection in long time series of images.

Taxonomy of CD Problems

1. Binary change detection

- ✓ Goal: production of binary maps in which changed and unchanged areas are separated.
- ✓ Number of images: 2 (or pairs of images extracted from a series).
- ✓ Application domain: detection of abrupt (step) changes.

Sardinia Island,
July 2013 (Landsat 8)

Sardinia Island,
August 2013 (Landsat 8)

Map of burned areas

Taxonomy of CD Problems

2. Multiclass change detection

- ✓ Goal: generation of a change-detection map in which land-cover transitions are explicitly identified.
- ✓ Number of images: 2 (or pairs of images extracted from a series).
- ✓ Application domain: updating thematic maps, detection of multiple changes.

May (Landsat)

July (Landsat)

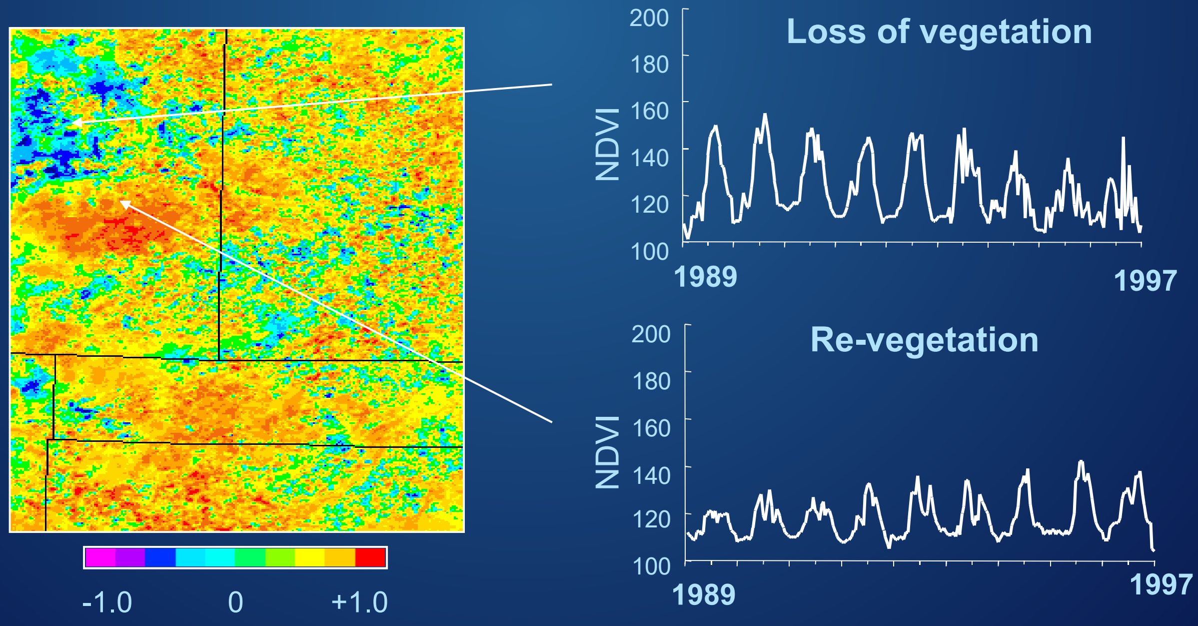
Thematic Map

- URBAN / URBAN
- BARE SOIL / SUGAR BEET
- WHEAT / BARE SOIL
- BARE SOIL / CORN
- BARE SOIL / SOYBEAN

Taxonomy of CD Problems

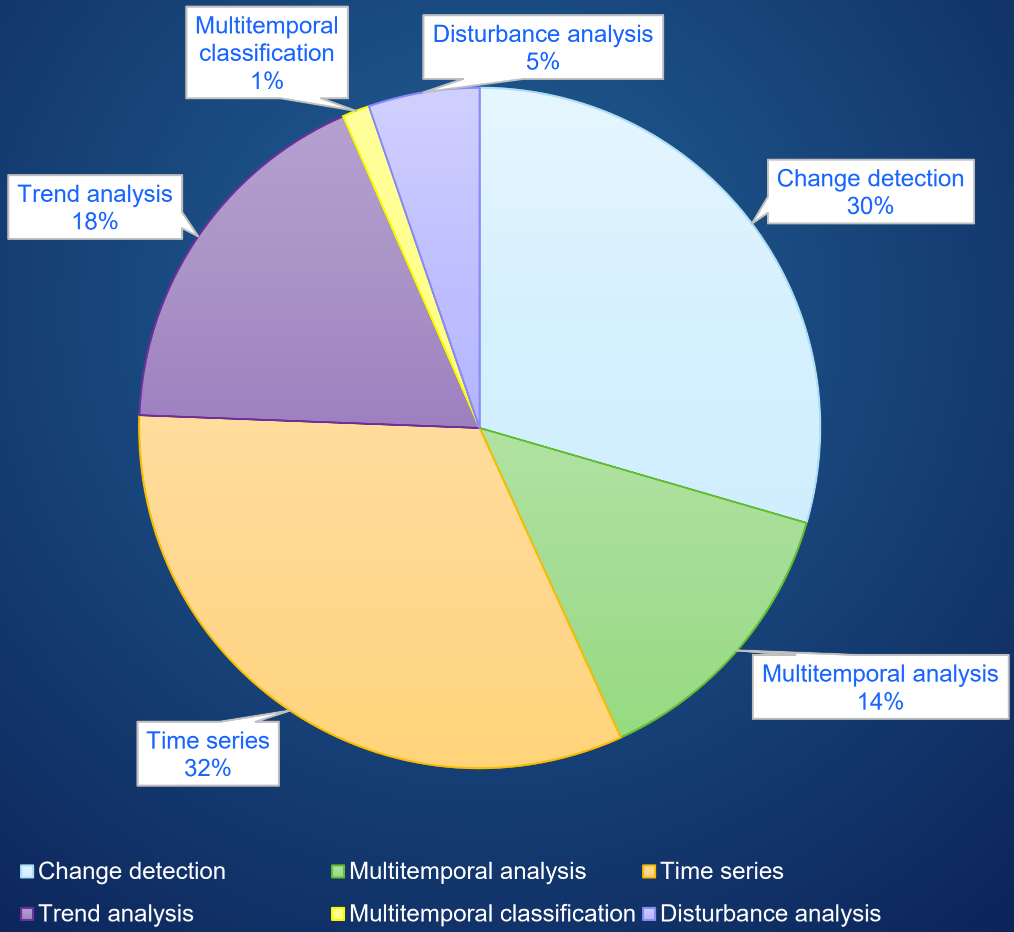
3. Change detection in long time series of images

- ✓ Goal: detection of changes associated with modifications of the behavior of the temporal signature of a land cover between two time series (detection of long term changes).
- ✓ Number of images: 2 time series made up on n images (n>>2).
- ✓ Application domain: monitoring seasonal/annual changes.

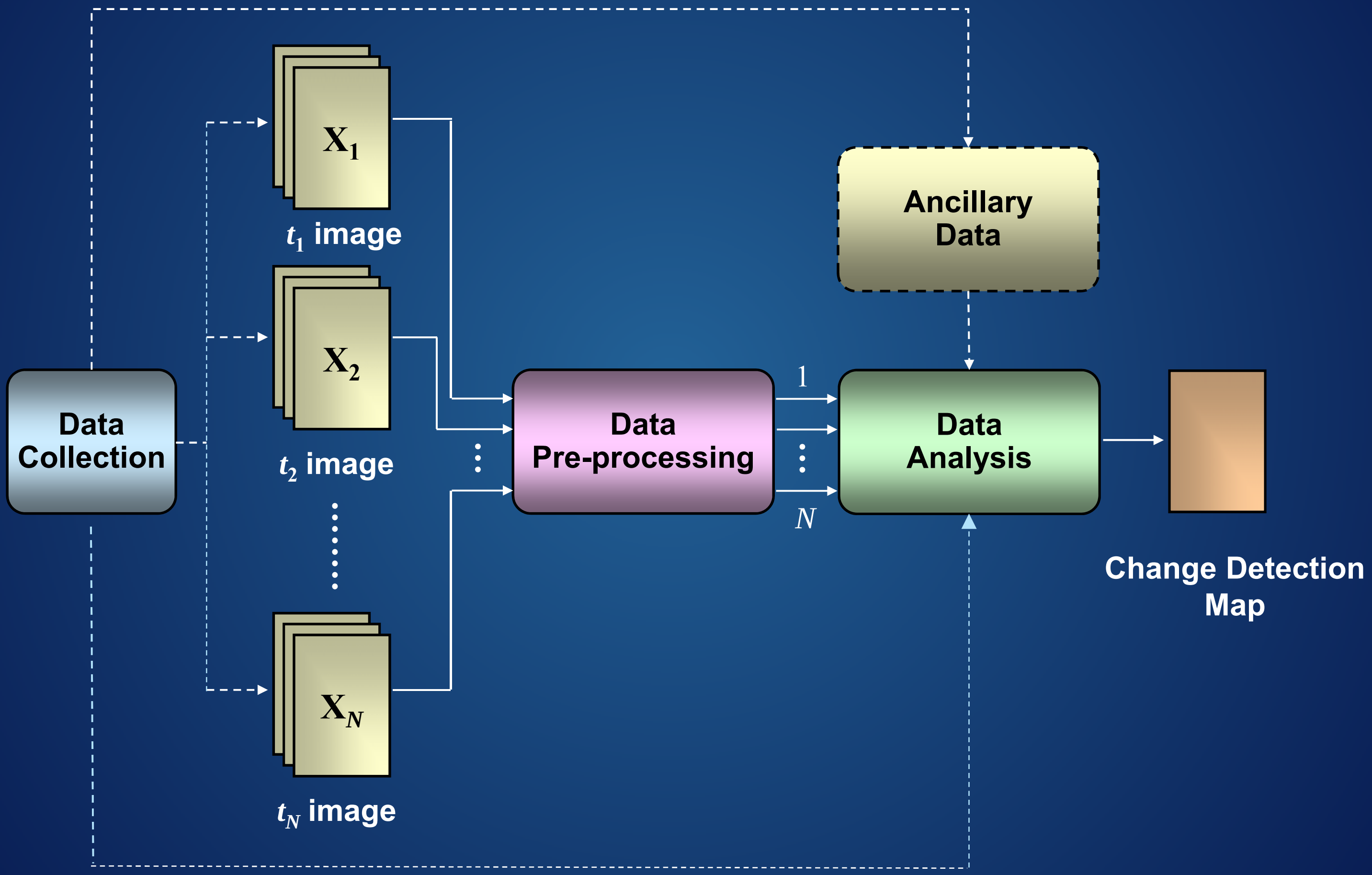


Distribution of Papers per Topics

Distribution of the overall number of published papers versus different topics related to multitemporal data between 1990 and 2016 (Source: Scopus)



Change Detection Architecture



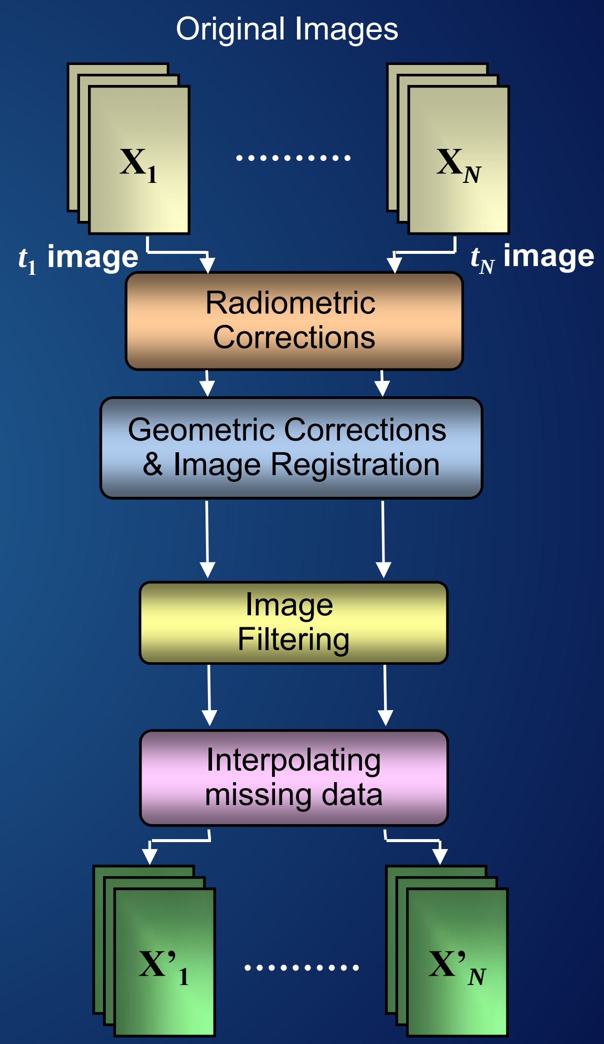
Data Pre-processing

Very important with optical images

Mandatory in all change-detection techniques

Depends on the specific sensor considered and on the quality of the considered images

Depends on the requested acquisition frequency and data availability (careful application, see information theory!)



Data Pre-processing: Radiometric Corrections

Differences in light and atmospheric conditions between the two acquisition times can be mitigated by applying radiometric calibration to the images. Two different approaches can be applied:

- Absolute calibration: digital numbers are transformed into the corresponding ground reflectance values (radiometric transfer models, regression algorithms applied to ground-reflectance measurements collected during the data acquisition phase).

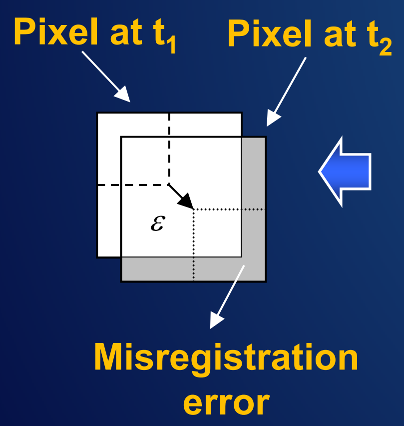
- Relative calibration: modification of the histograms, so that the same gray-levels values in the two images can represent the same reflectance values, whatever the reflectance values on the ground may be (histogram matching).

The choice of one of the two approaches depends on the particular application considered and on the specific information available.

Data Pre-processing: Image Registration

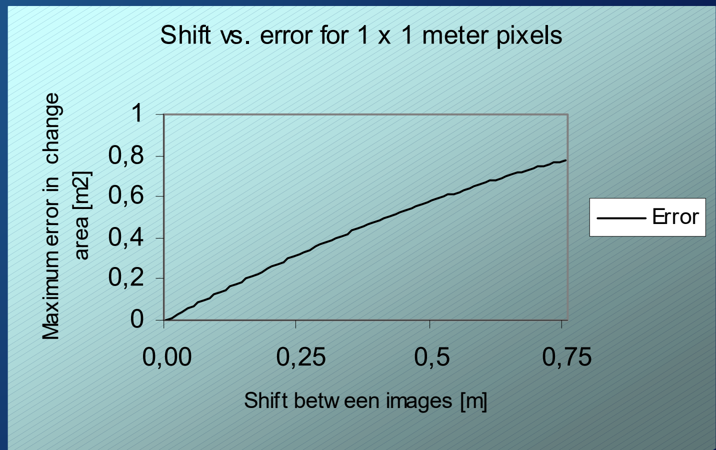
Generally it is not possible to obtain a perfect alignment between multitemporal images. This is mainly due to local defects in the geometries of the images.

Residual misregistration results in a very critical source of noise, which is called "registration noise"



Generic effect of misregistration

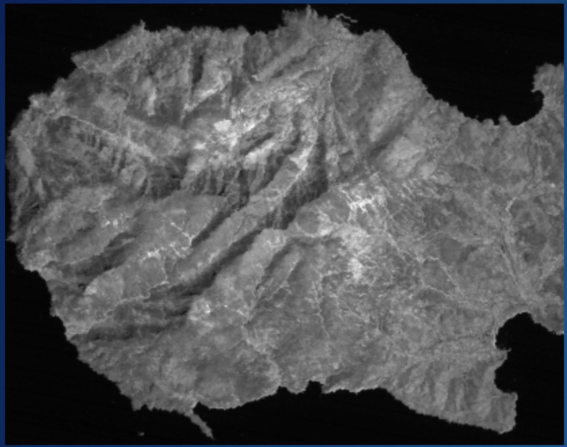
Error in area as a function of the displacement in high resolution sensors



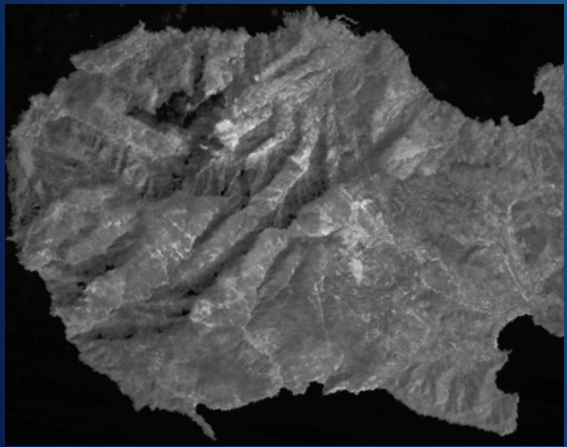
Data Pre-processing: Registration Noise Effects

Elba Island, Landsat-TM4

August 1992



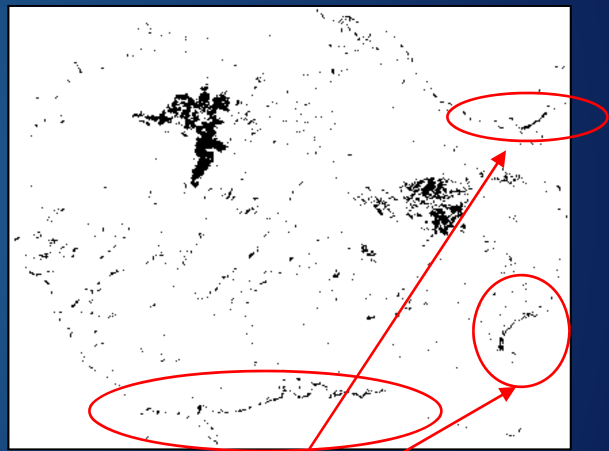
September 1994



t_1 image

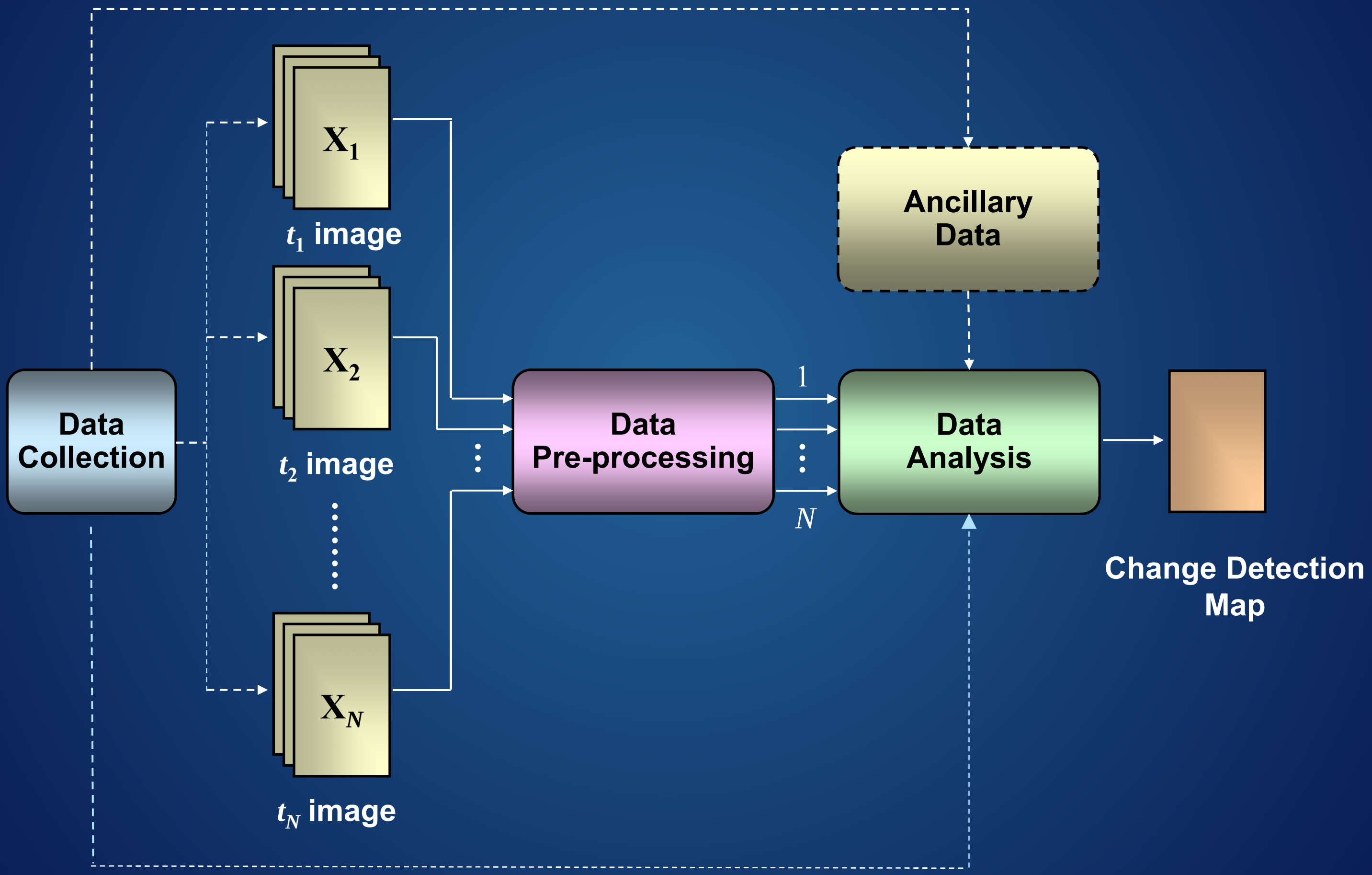
t_2 image

Change-detection map



Registration noise

Change Detection Architecture

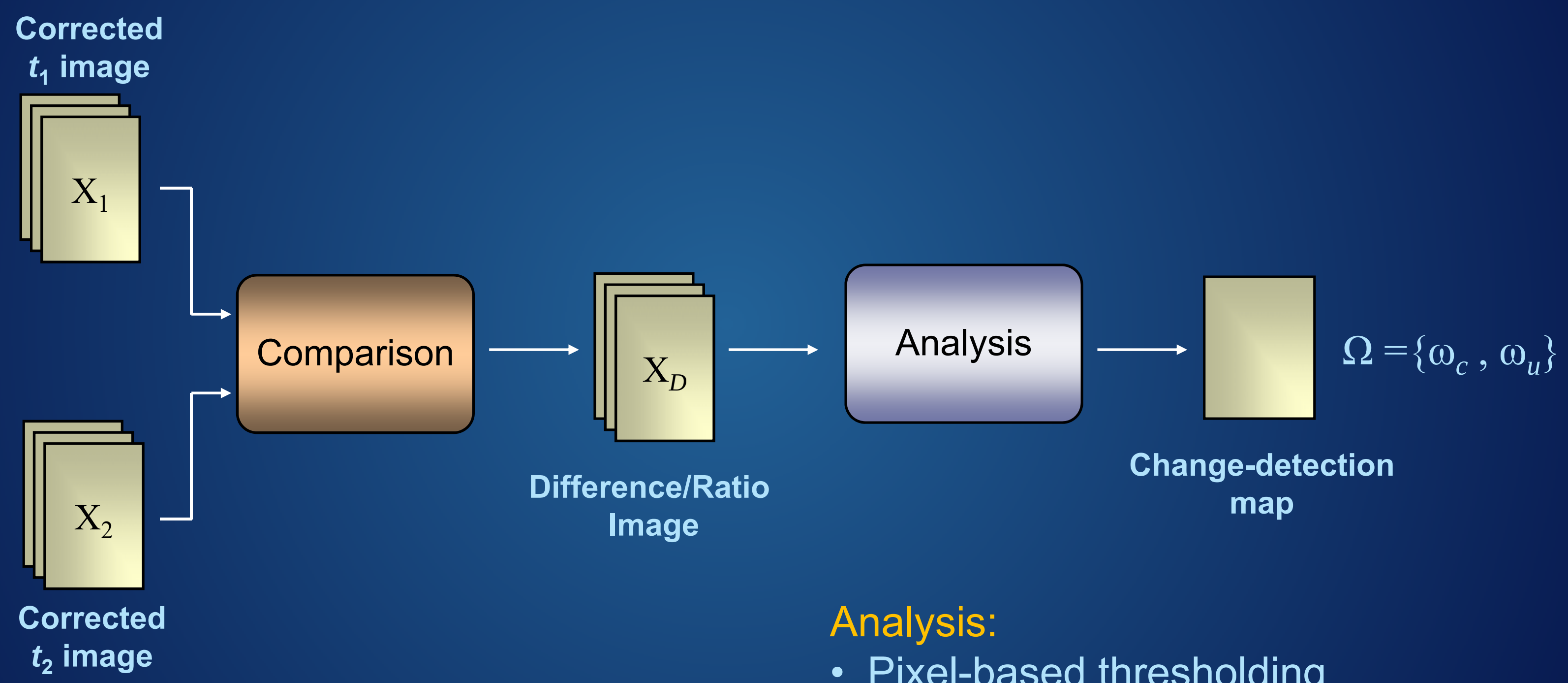


Binary Change Detection in Remote Sensing

Binary change detection in remote-sensing images is characterized by several peculiar factors that render ineffective some of the multitemporal image analysis techniques typically used in other application domains. Some of these factors are:

- ✓ Differences in light conditions, sensor calibration, and ground moisture at the two acquisition dates considered;
- ✓ Absence of a reference background;
- ✓ Lack of a priori information about the shapes of changed areas;
- ✓ Non-perfect alignment (registration noise) between the two considered images;
- ✓ Different acquisition conditions of multitemporal images (view angle, shadows, etc.).

Binary CD: Typical Architecture



Analysis:
- Pixel-based thresholding
- Context-based approaches

CD in Multispectral Images: Comparison Operators

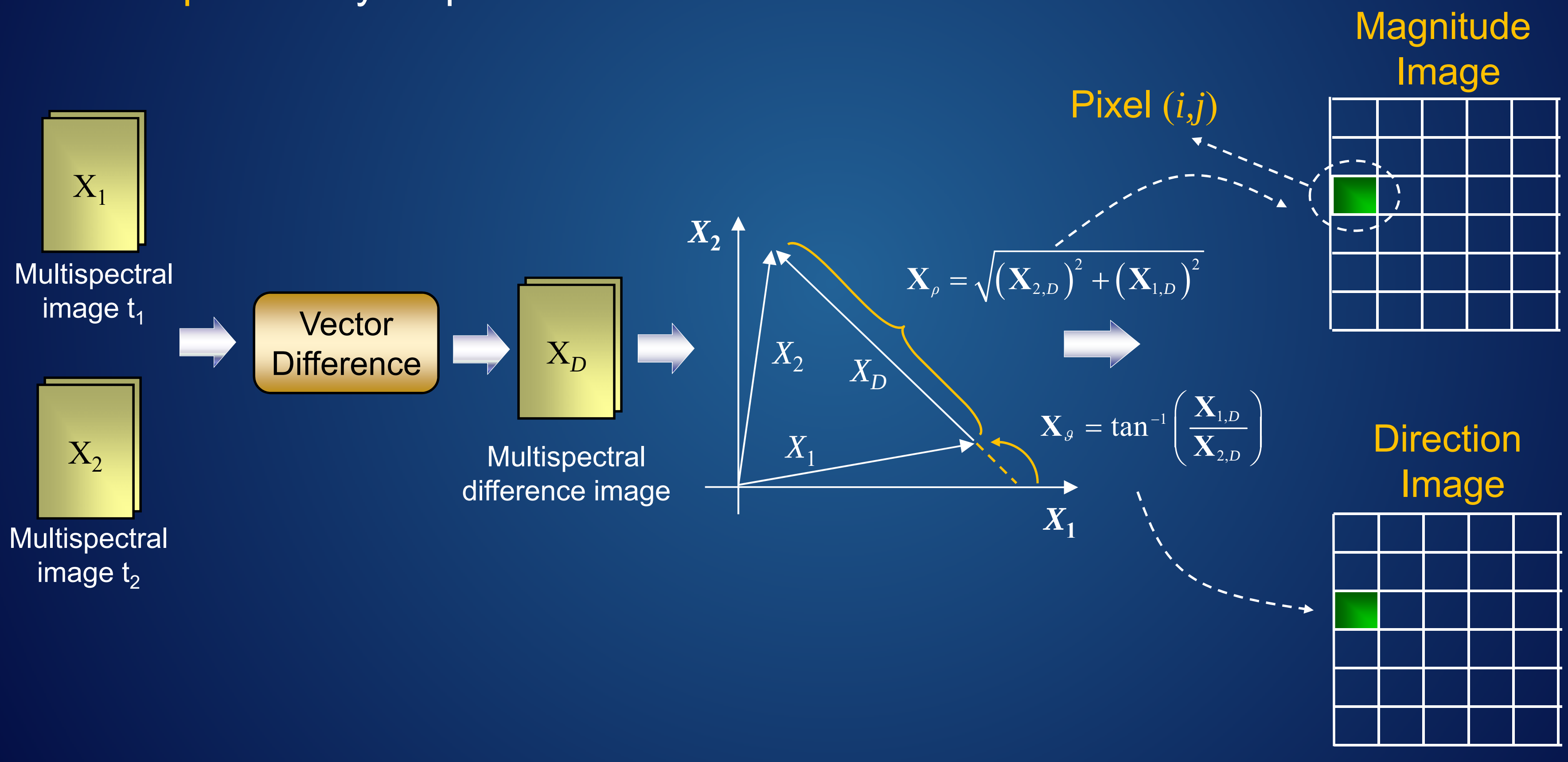
Technique	Feature vector f_k at the time t_k	Computation of X_D
Univariate image differencing	$f_k = X_k^b$	$X_D = f_1 - f_2 + C$
Vegetation index differencing	$f_k = V_k$	$X_D = f_1 - f_2 + C$
Change vector analysis	$f_k = [X_k^1, .., X_k^m]$	$X_D = \| f_1 - f_2 \|$
Regression	$f_1 = X_1^b$ and $f_2 = \hat{X}_2^b$	$X_D = f_1 - f_2 + C$
Multivariate Alteration Detection (MAD)	$f_k = [X_k^1, .., X_k^m]$	$X_D = a^T f_2 - b^T f_1$

b: variable associated with the spectral channel
k: variable associated with the acquisition date

F. Bovolo, L. Bruzzone, "The Time Variable in Data Fusion: a Change Detection Perspective," *IEEE Geoscience and Remote Sensing Magazine*, Vol. 3, No 3, 2015.

Change Vector Analysis (CVA)

Assumption: only 2 spectral channels are considered for each date.



Polar Change Vector Analysis

Polar Domain

$$D = \{\rho, \vartheta : 0 \le \rho < \rho_{max} \text{ and } 0 \le \vartheta < 2\pi\}$$

ρ -> Random variable associate to magnitude image X_ρ

ϑ -> Random variable associate to direction image X_ϑ

Circle of unchanged pixels

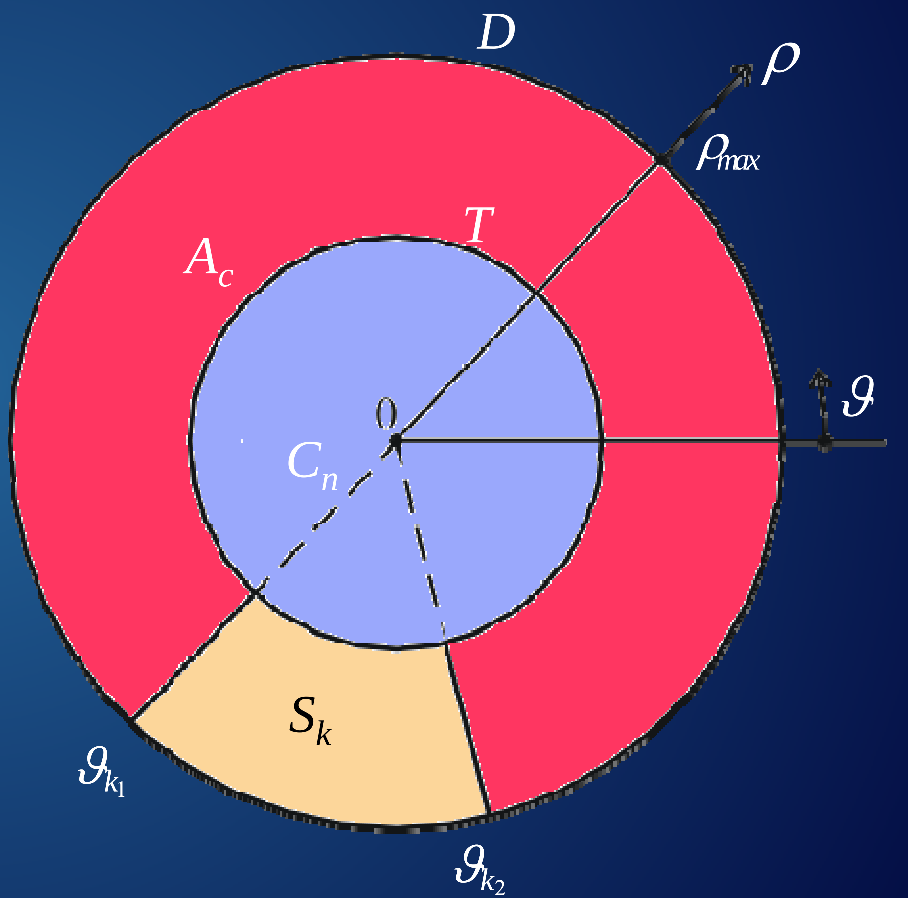
$$C_n = \{\rho, \vartheta : 0 \le \rho < T \text{ and } 0 \le \vartheta < 2\pi\}$$

Annulus of changed pixels

$$A_c = \{\rho, \vartheta : T \le \rho \le \rho_{max} \text{ and } 0 \le \vartheta < 2\pi\}$$

Sector of changed pixels

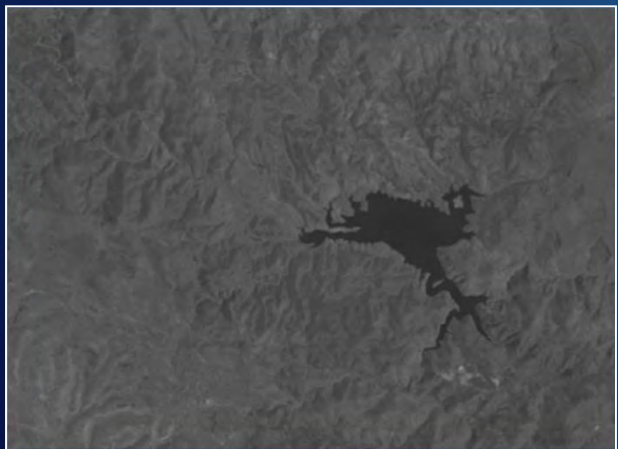
$$S_k = \{\rho, \vartheta : \rho \ge T \text{ and } \vartheta_{k_1} \le \vartheta < \vartheta_{k_2},\ 0 \le \vartheta_{k_1} < \vartheta_{k_2} < 2\pi\}$$

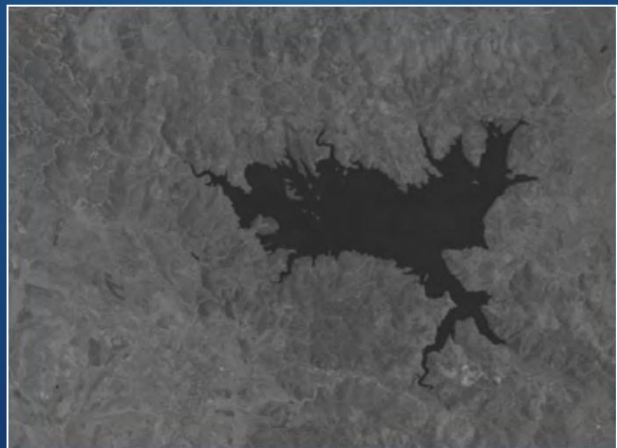


Polar Change Vector Analysis: Example

Study area: Lake Mulargia, Sardinia Island (Italy).

Multitemporal data set: a portion of 412×300 pixels of two images acquired by the TM sensor of Landsat-5 satellite in September 1995 and July 1996.

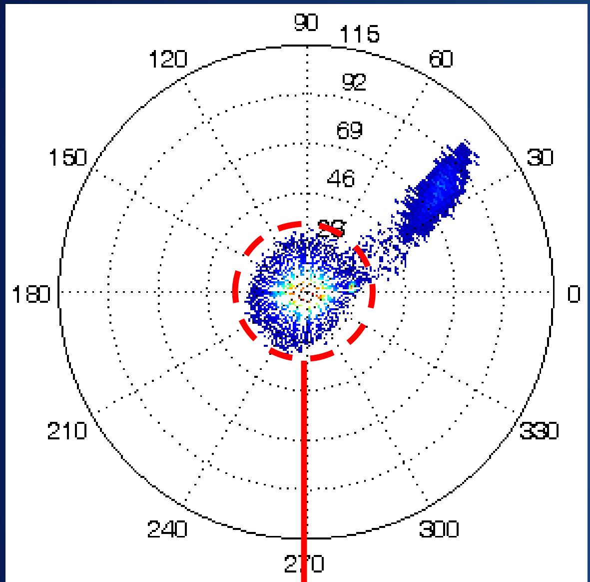

Before Change


After Change

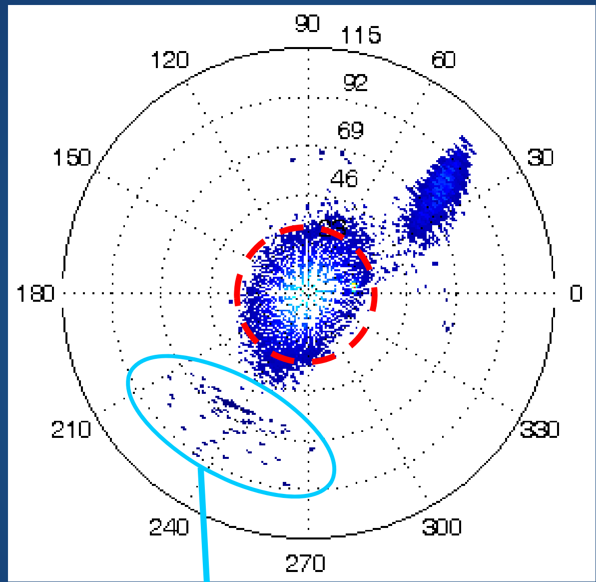

Reference Map

Polar Change Vector Analysis: Example

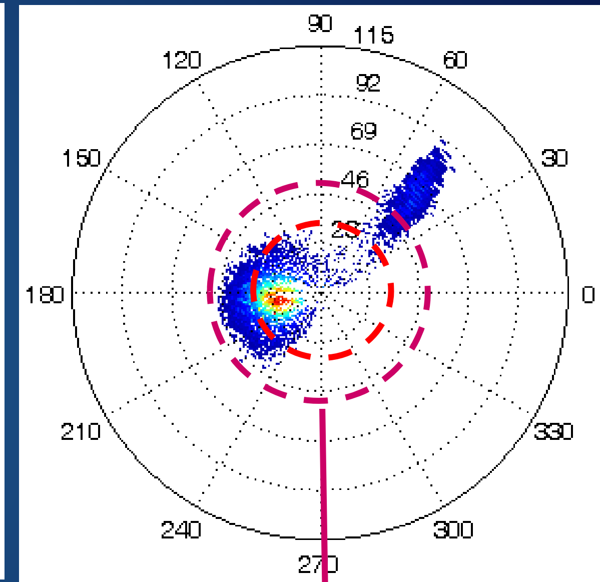
Corrected Images (Ideal case)



Registration noise effects



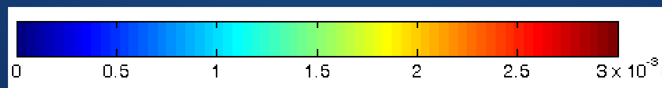
Radiometric difference effects



Optimal threshold value on the magnitude variable: ideal case

Registration noise effects

Threshold value on the magnitude variable: radiometric distortion case



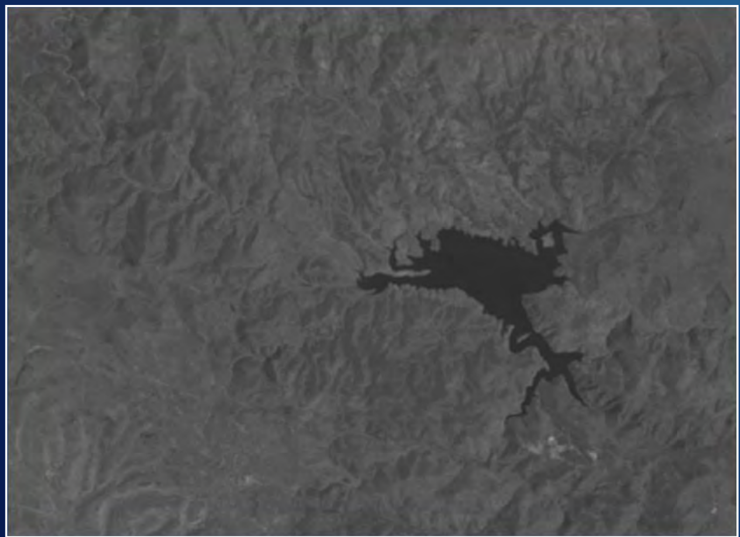
F. Bovolo, L. Bruzzone, A Theoretical Framework for Unsupervised Change Detection Based on Change Vector Analysis in Polar Domain, *IEEE Transactions on Geoscience and Remote* Sensing, Vol. 45, No.1, 2007, pp.218-236.

Polar Change Vector Analysis: Example

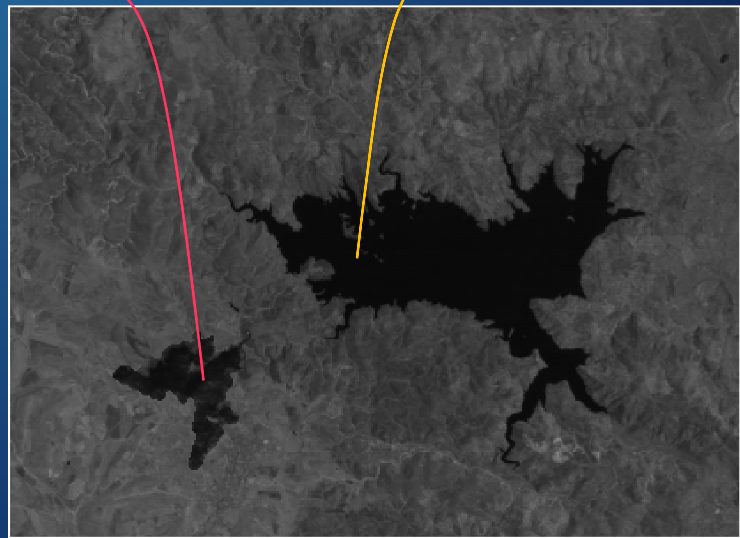
Study area: Lake Mulargia, Sardinia Island (Italy).

Multitemporal data set: a portion of 412×300 pixels of two images acquired by the TM sensor of Landsat-5 satellite in September 1995 and July 1996.

Changes: 1 natural change, 1 simulated change.

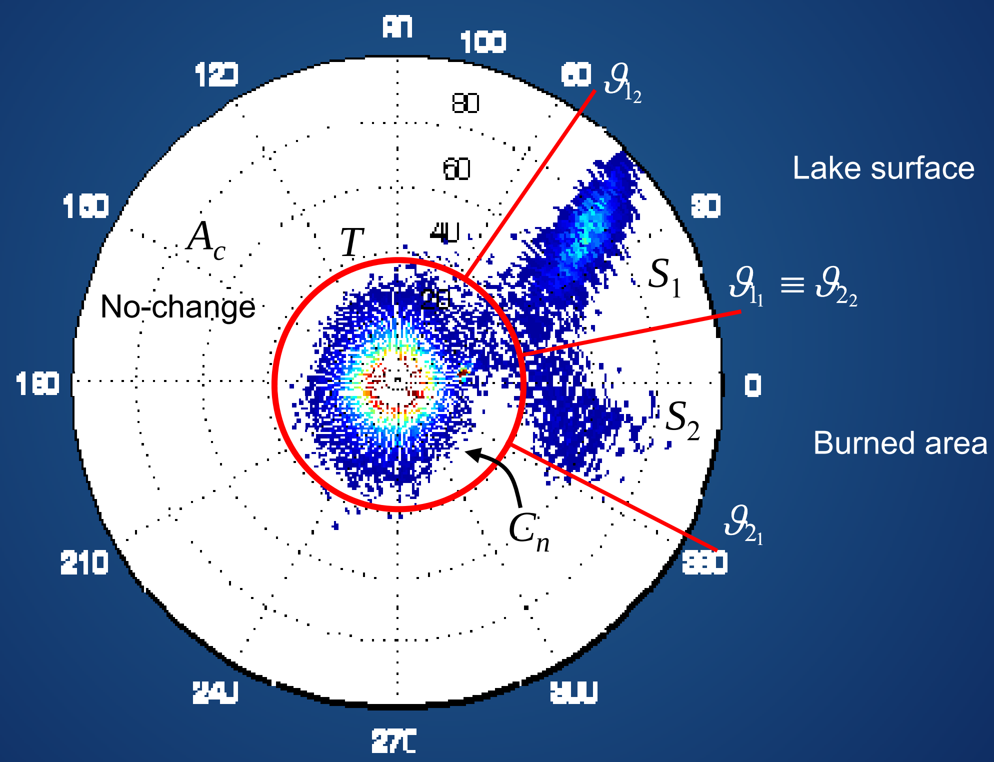


September 1995



July 1996

Polar Change Vector Analysis: Example



F. Bovolo, S. Marchesi, L. Bruzzone, “A Framework for automatic and unsupervised detection of multiple changes in multitemporal images,” IEEE Transactions on Geoscience and Remote Sensing, Vol. 50, No. 6, pp. 2196–2212, 2012.

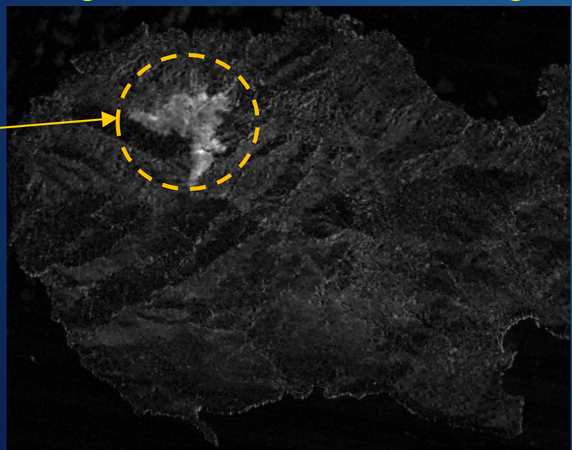
Example: CD in Multispectral Images

Landsat TM, Pre-event

Landsat TM, Post-event

Magnitude Difference Image

Burned area

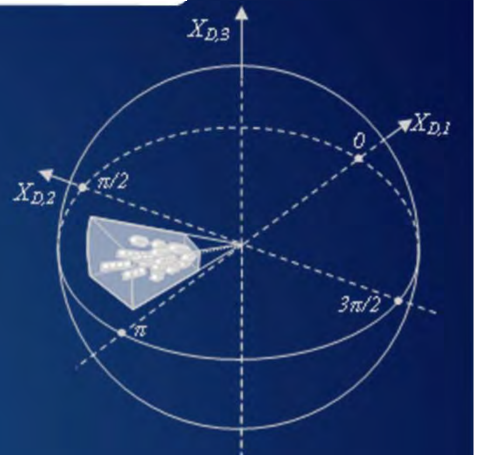


Change Detection Map (Burned Area)

Landsat 5 Thematic Mapper images of a forest fire in the Island of Elba, Italy

Change Vector Analysis: Advanced Concepts

- ✓ There have been many recent developments related to CVA:
  - ✓ Compressed CVA [2];
  - ✓ Adaptive change-specific semisupervised CVA [3];
  - ✓ Advanced statistical modeling and thresholding [4];
  - ✓ Deep CVA (based on features extracted via deep learning).



September 2007

September 2008

September 2010

September 2011

Brasilian Amazan: Landsat Thematic Mapper false color compositions. Magenta color highlogths deforestation

F. Bovolo, S. Marchesi, L. Bruzzone, “A Framework for Automatic and Unsupervised Detection of Multiple Changes in Multitemporal Images”, *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 50, No. 6, pp. 2196-2212, 2011.

D. Capella Zanotta, L. Bruzzone, F. Bovolo, Y.E. Shimabukuro, “An Adaptive Semi-Supervised Approach to the Detection of User-Defined Recurrent Changes in Image Time Series,” IEEE Transactions on Geoscience and Remote Sensing, Vol. 53, pp. 3707 - 3719, 2015.

M. Zanetti, F. Bovolo, L. Bruzzone Rayleigh-Rice Mixture Parameter Estimation via EM Algorithm for Change Detection in Multispectral Images, I*EEE Transactions on Image Processing*, Vol. 24, 2015, pp.5004-5016.

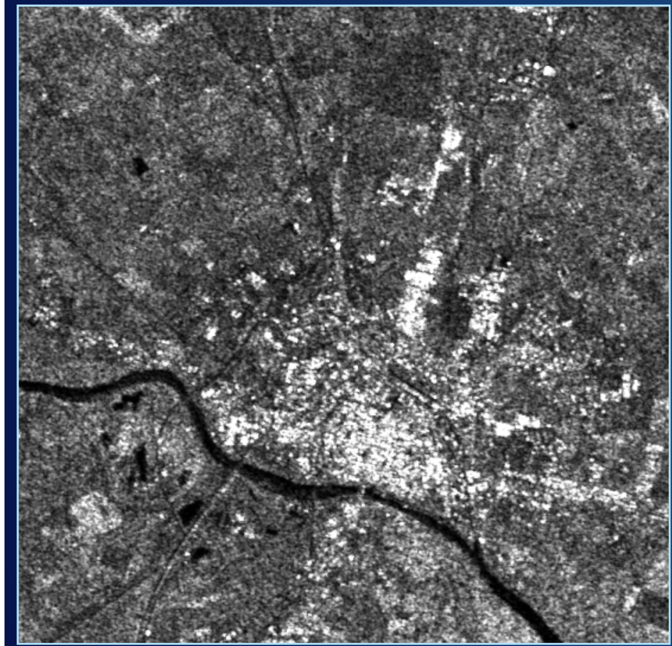
CD in SAR Images: Comparison Operators

Technique	Feature vector f_k at the time t_k	Computation of X_D
Image rationing	$f_k = X_k$	$X_D = f_1 / f_2$
Kullback-Leibler distance (Similarity measures)	$f_k = p(X_k)$	$KL(X_1 \mid X_2) = \int \log(f_1 / f_2) f_1$
Difference of scattering matrix element products	$f_k = [S_{HH} S_{HH}^*]$	$X_D = f_1 - f_2$
Difference of scattering matrix amplitude correlation coefficients	$f_k = \left[\dfrac{S_{HH} S_{VV}^*}{\sqrt{\lvert S_{HH} \rvert^2 \lvert S_{VV} \rvert^2}} \right]$	$X_D = f_1 - f_2$

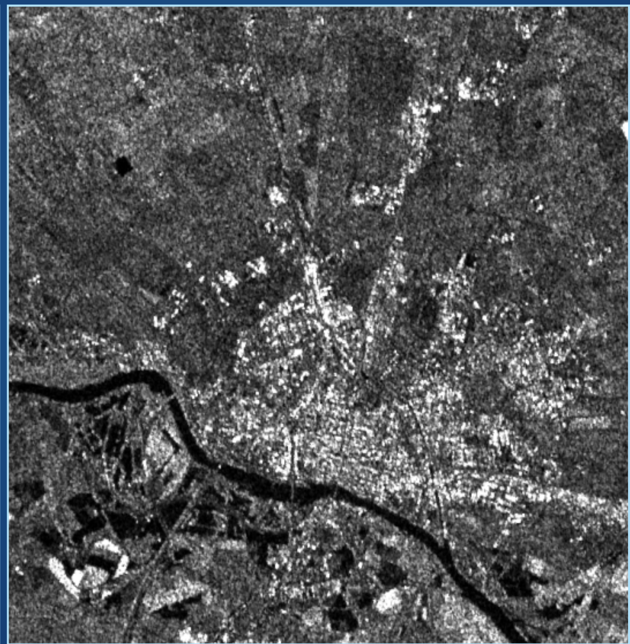
k: variable associated with the acquisition date

Example: CD in SAR Images

ERS-2, Pre-event Image



ERS-2, Post-event Image



Change Detection Map
(Flooded Area)

ERS-2 SAR images of a flood in the City of Pavia, Italy

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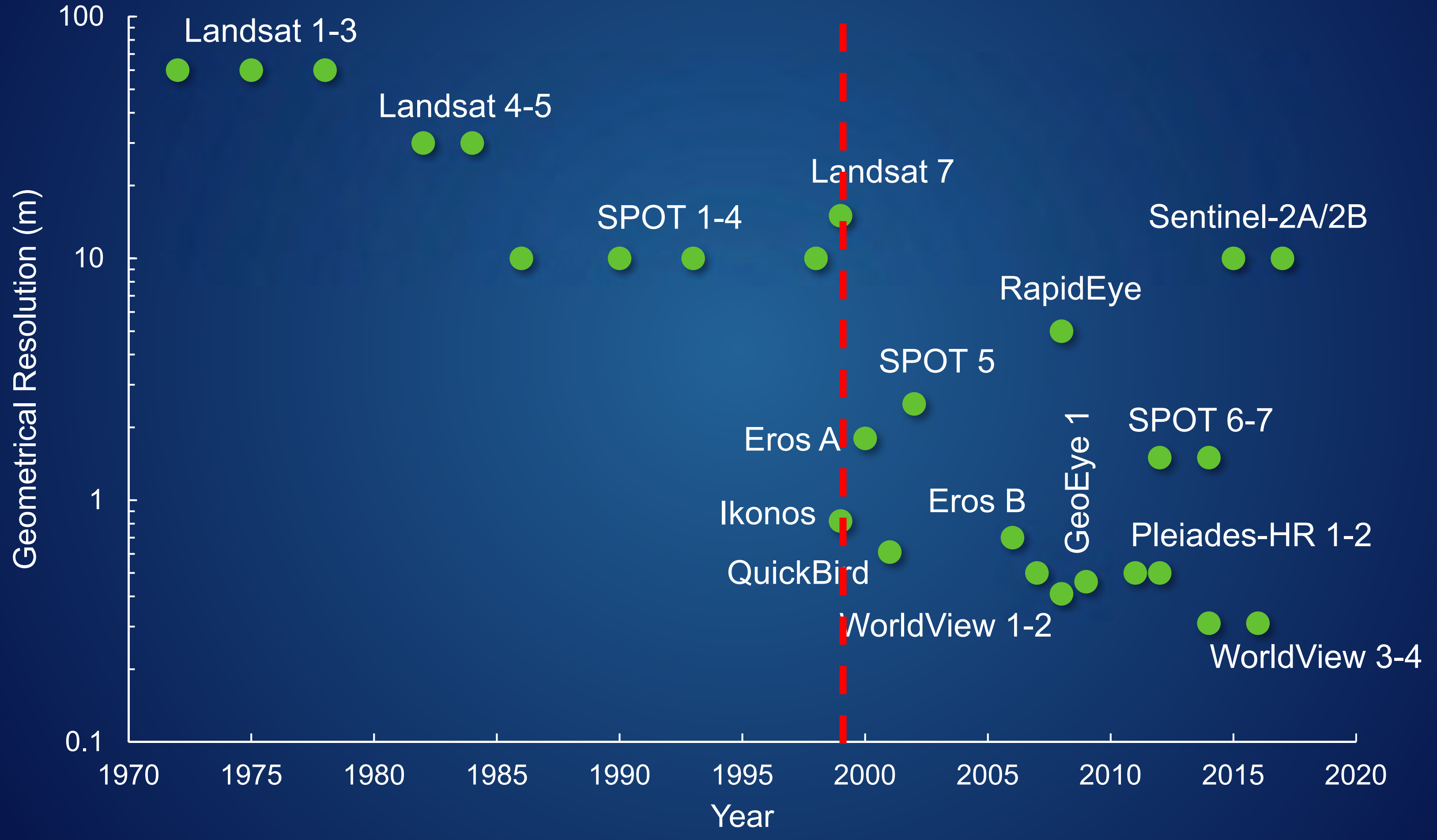
2. Change Detection in Very High Resolution Multispectral Images

New Satellites with VHR Multispectral (MS) Sensors



CD in Multitemporal VHR MS images

July 2006

October 2005

Quickbird images of the city of Trento (Italy)

CD in Multitemporal VHR MS images

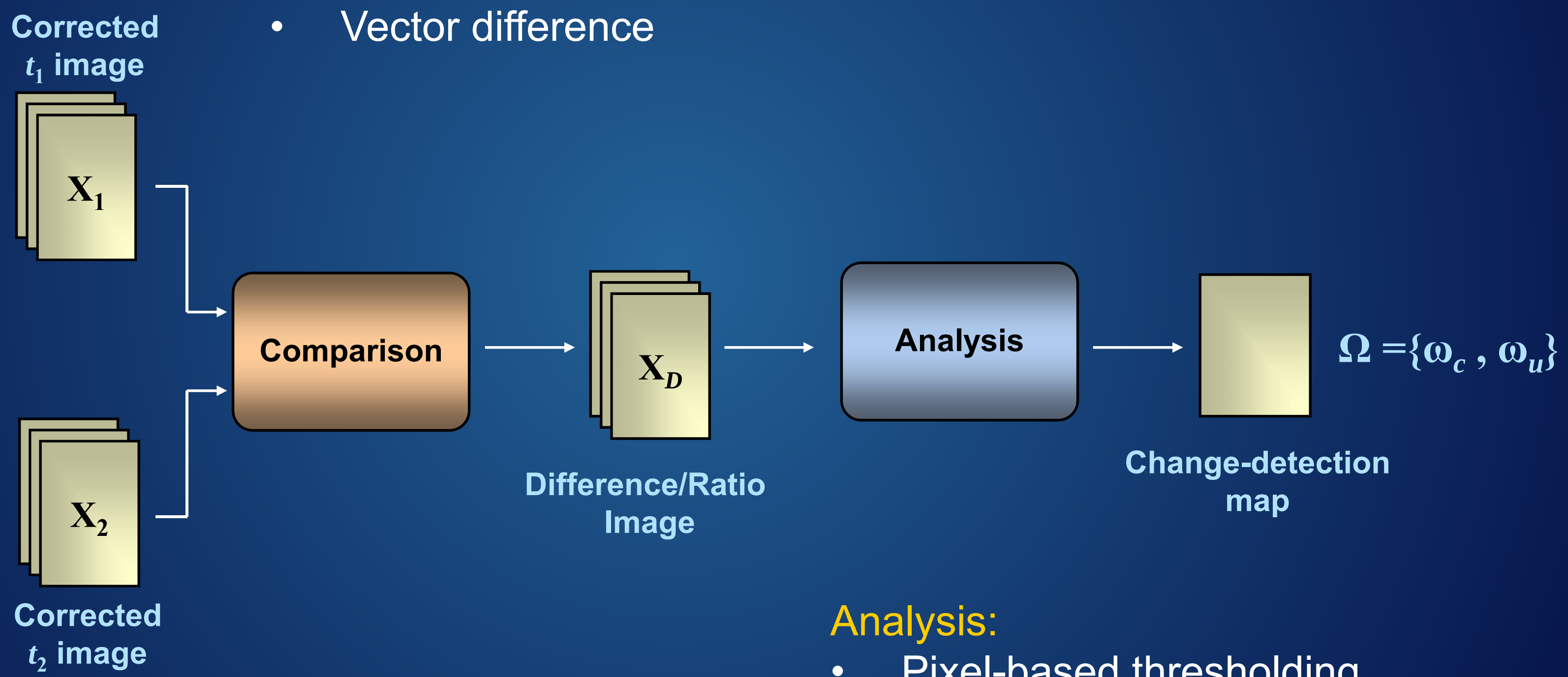
October 2005

July 2006

Quickbird images of the city of Trento (Italy)

Unsupervised CD: Typical Architecture

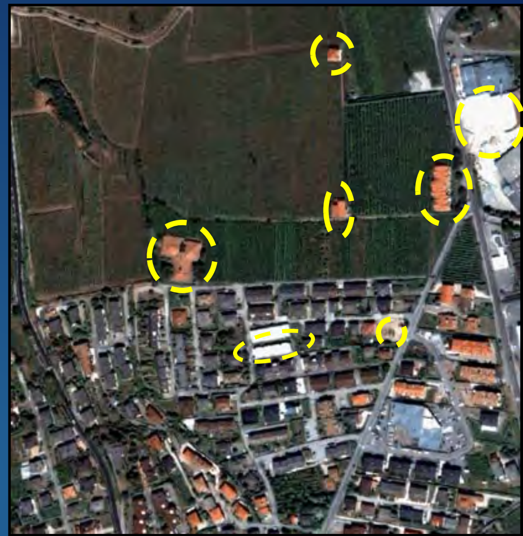
Comparison Operators:
- Difference
- Vector difference



Analysis:
- Pixel-based thresholding
- Context-based approaches

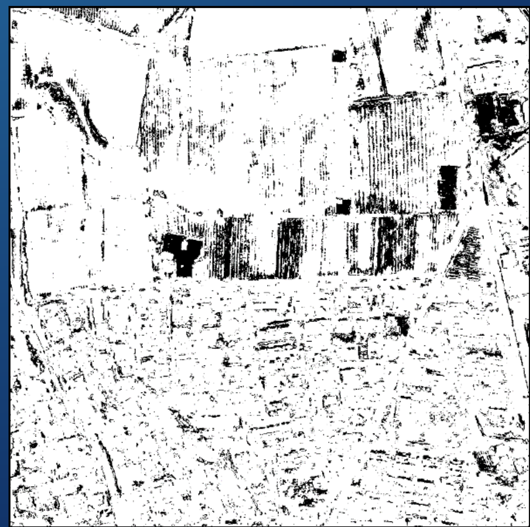
CD in Multitemporal VHR Images: Example

Quickbird, October 2004 (true color composition)



Quickbird, July 2006 true color composition

Magnitude Difference Image



Pixel-Based Change Detection Map

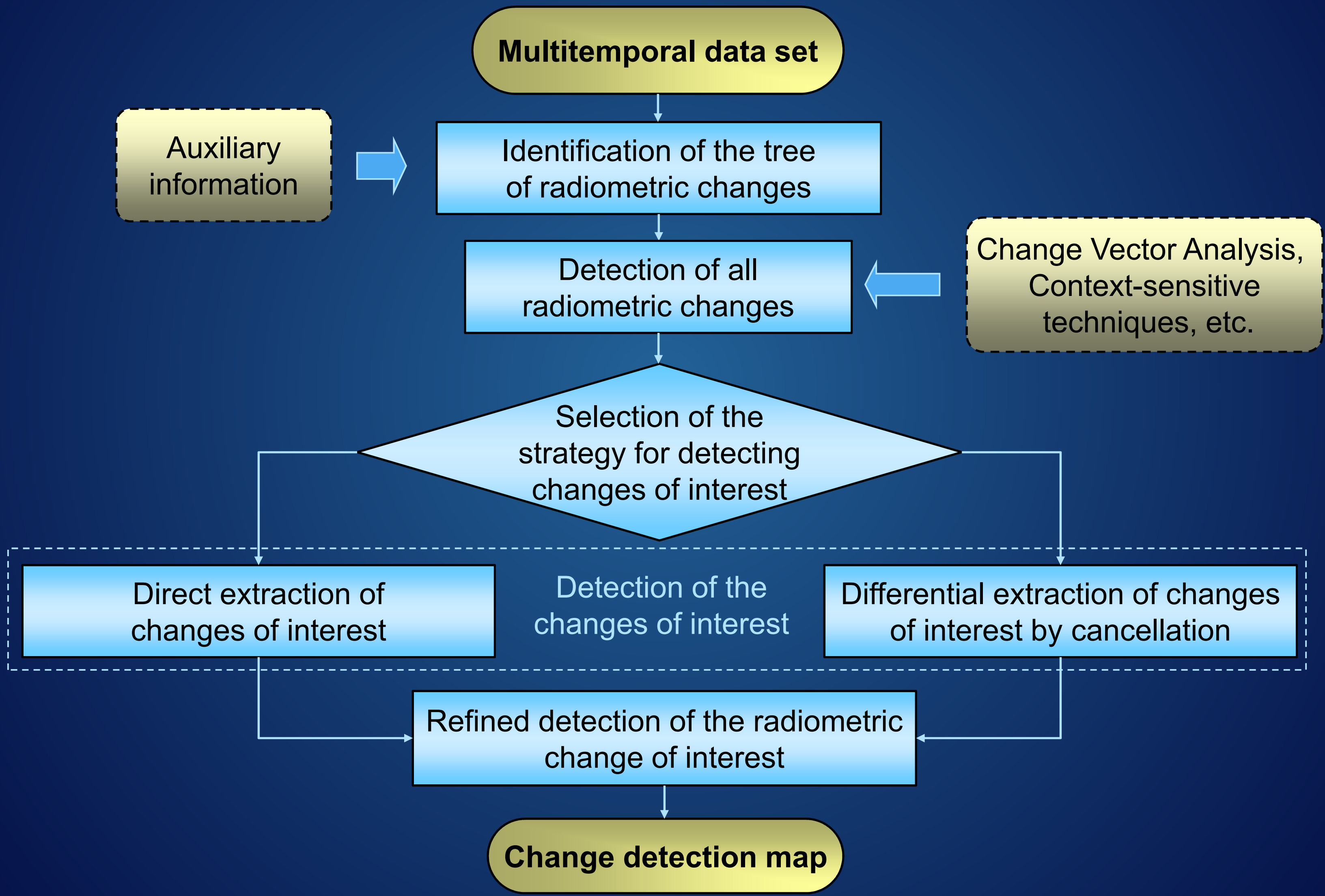
CD in Multitemporal VHR images

Change detection in VHR Images should exploit a top-down approach to the definition of the processing architecture. This approach should [4]:

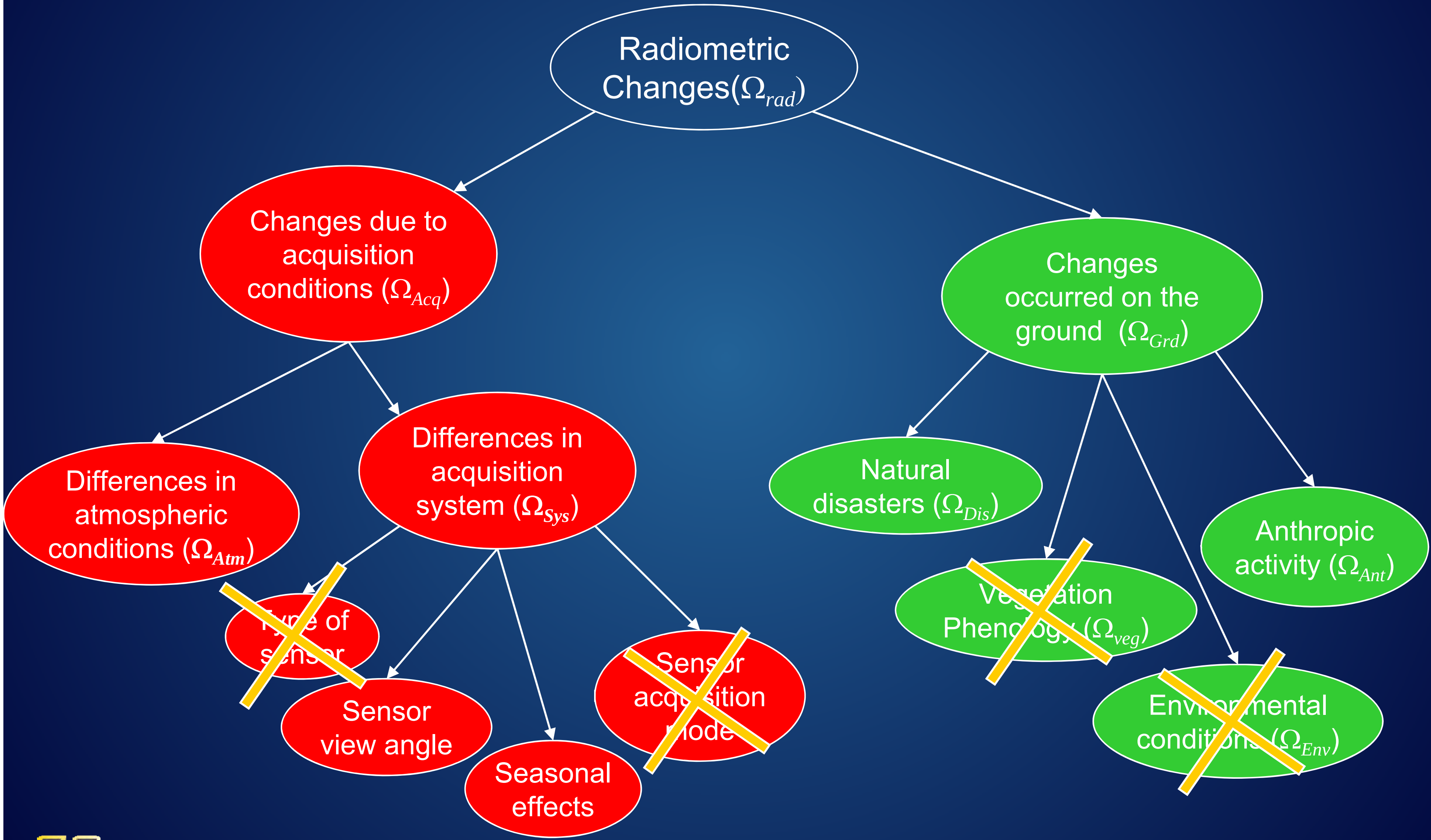
- ✓ explicitly model the presence of different radiometric changes on the basis of the properties of the considered images
- ✓ extract the semantic meaning of changes;
- ✓ identify changes of interest with strategies designed on the basis of the specific application;
- ✓ exploit the intrinsic multiscale properties of the objects and the high spatial correlation between pixels in a neighborhood.

L. Bruzzone, F. Bovolo, "A Conceptual Framework for Change Detection in Very High Resolution Remote Sensing Images," *Proceedings of IEEE*, Vol. 101, pp. 609-630, 2013.

CD in VHR MS Images: Architecture Design

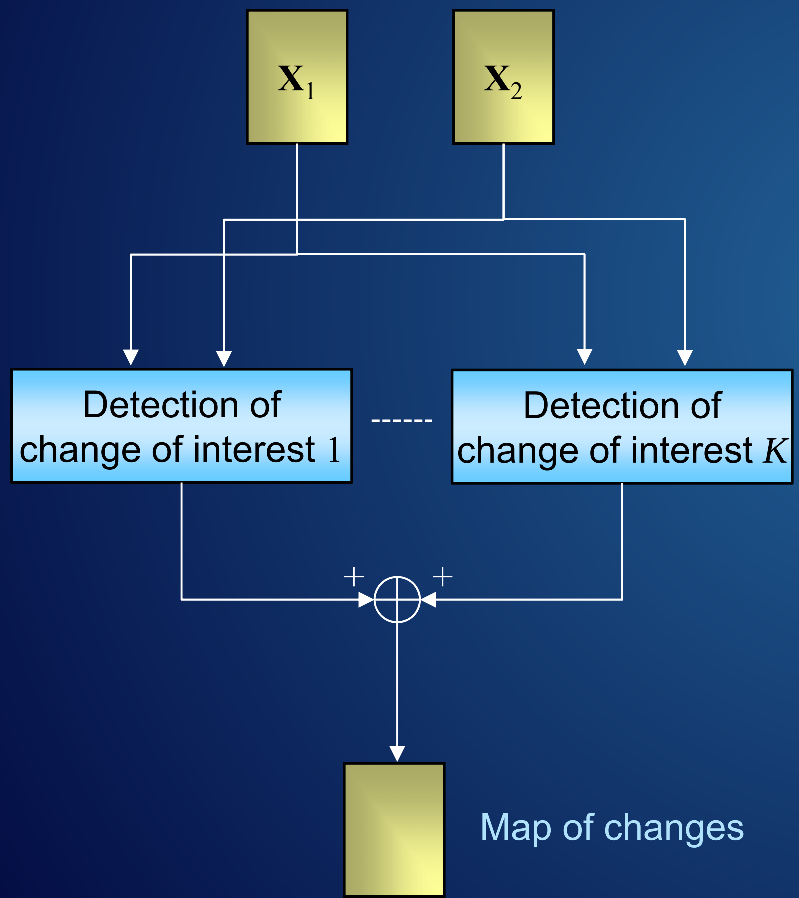


Identification of the Tree of Radiometric Changes

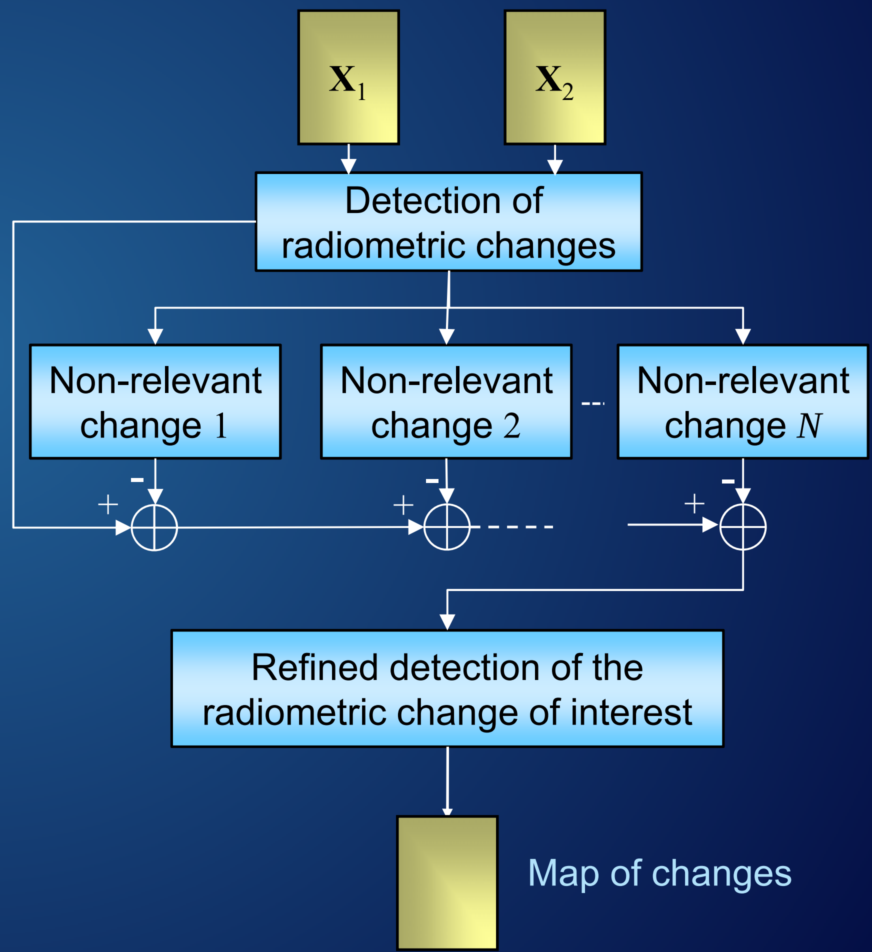


Detection of Changes of Interest

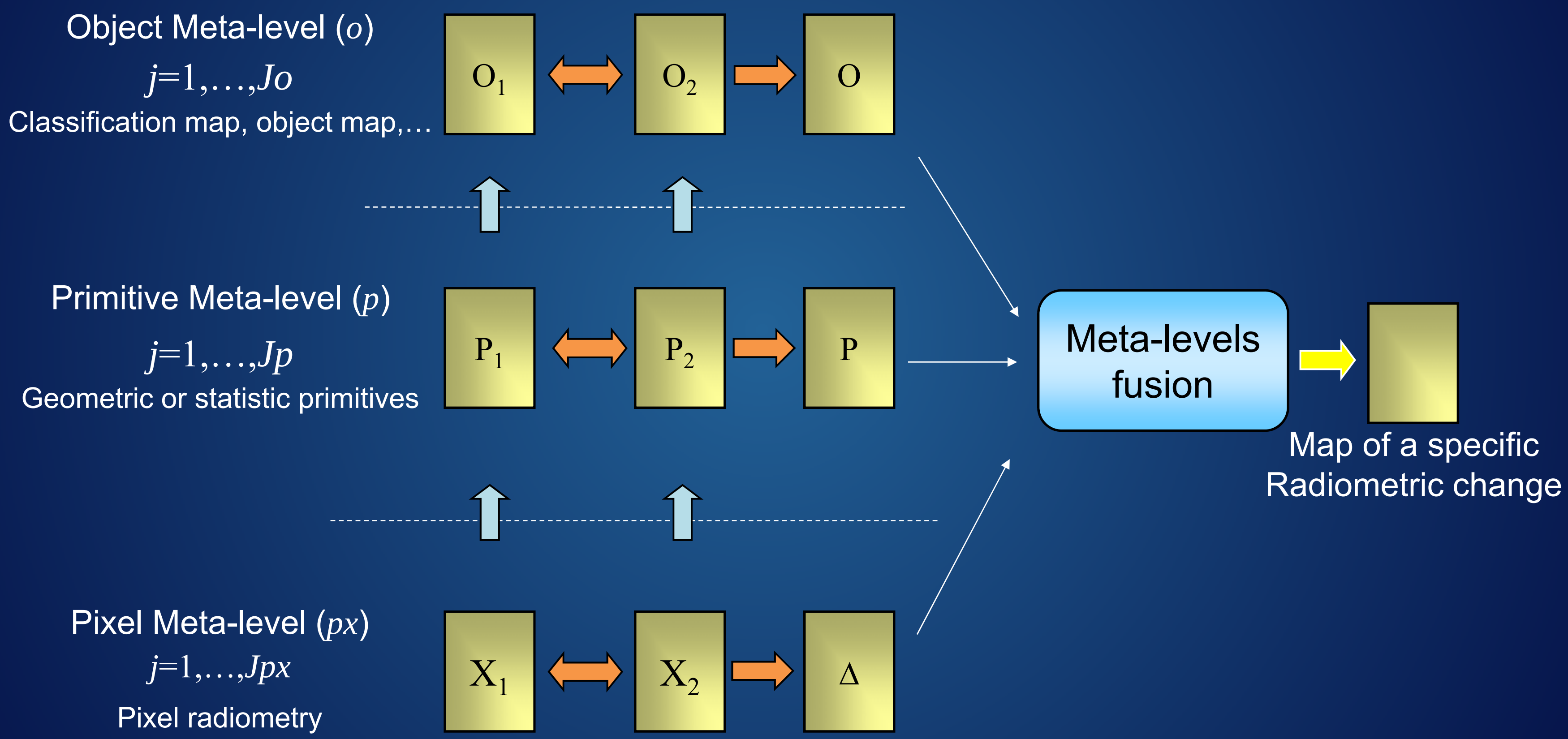
Direct detection



Differential detection by cancellation

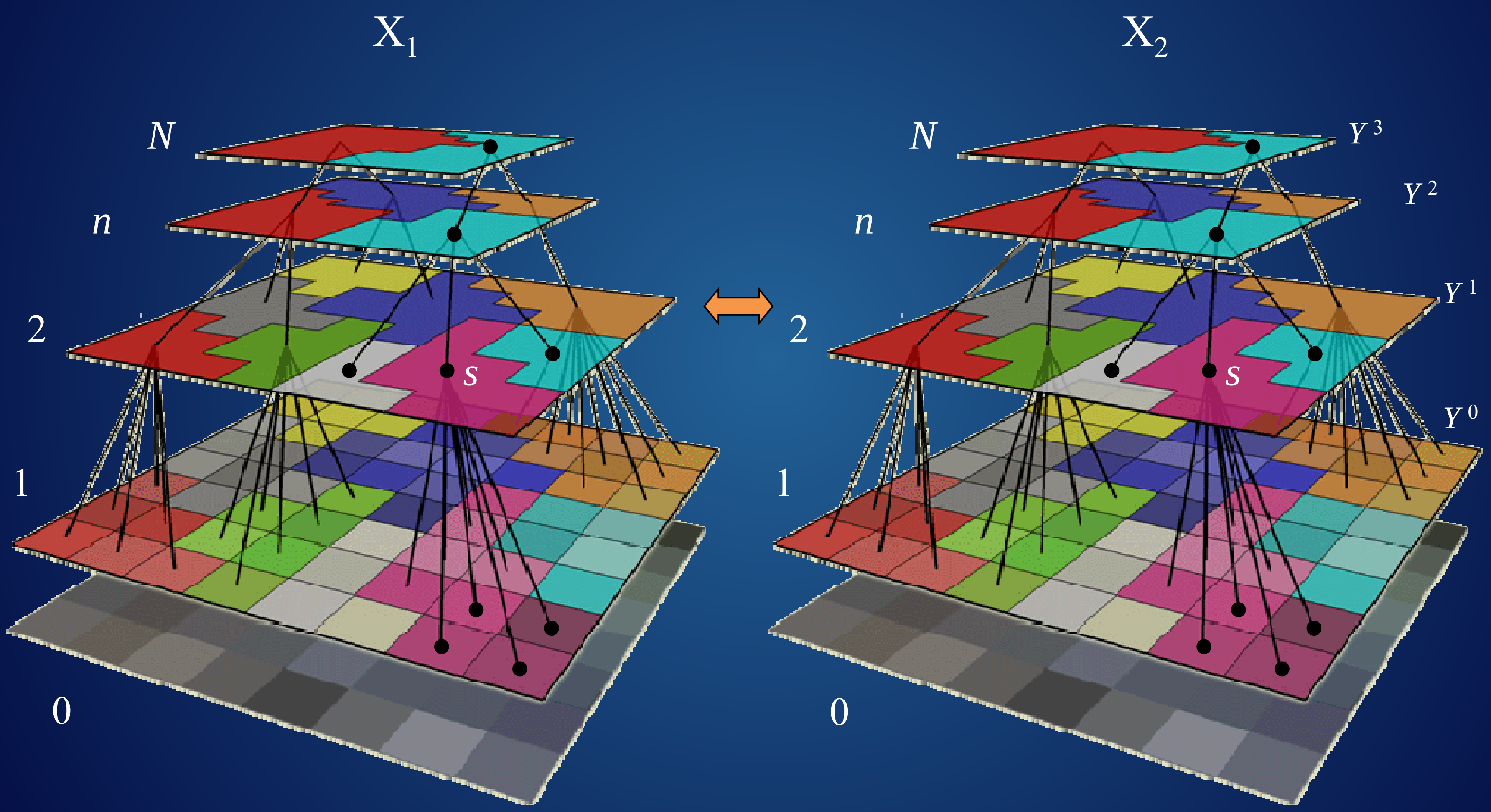


Multilevel Approach: Semantic of Changes



L. Bruzzone, F. Bovolo, "A Conceptual Framework for Change Detection in Very High Resolution Remote Sensing Images," *Proceedings of IEEE*, Vol. 101, pp. 609-630, 2013.

Multilevel Multitemporal Representation



Example: CD in VHR Optical Images

Study area: South part of Trento (Italy).

Multitemporal data set: portion (380×430 pixels) of two images acquired by the Quickbird satellite in October 2004 and July 2006.

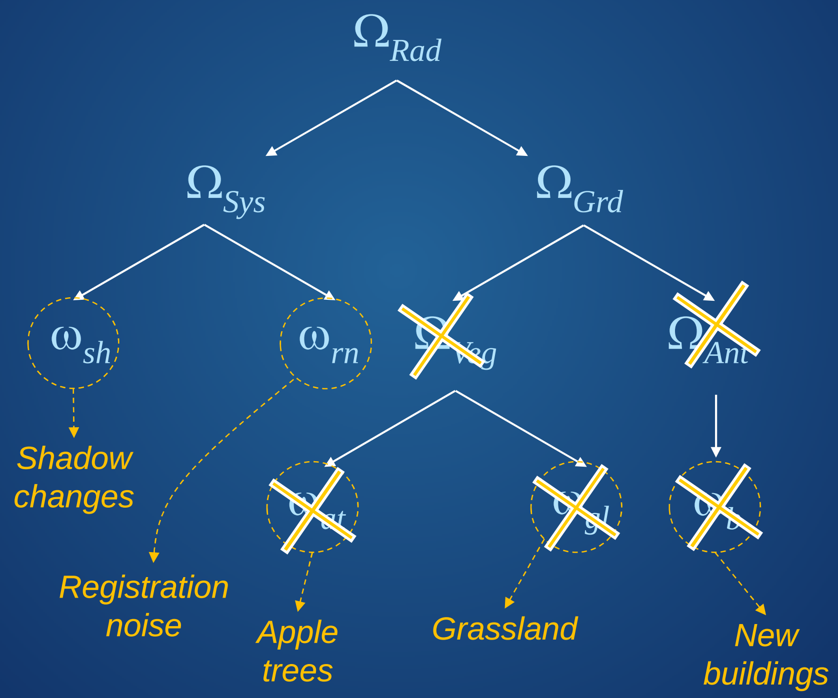
Causes of Change: changes on the ground, seasonal changes, registration noise.

October 2004

July 2006

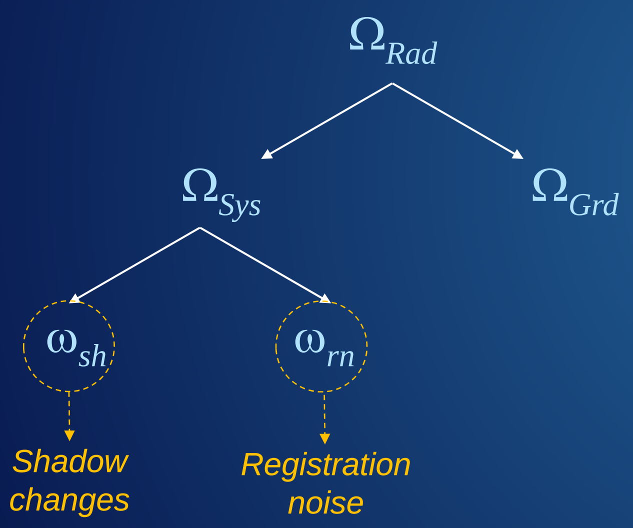
Reference Map

Identification of the Tree of Radiometric Changes

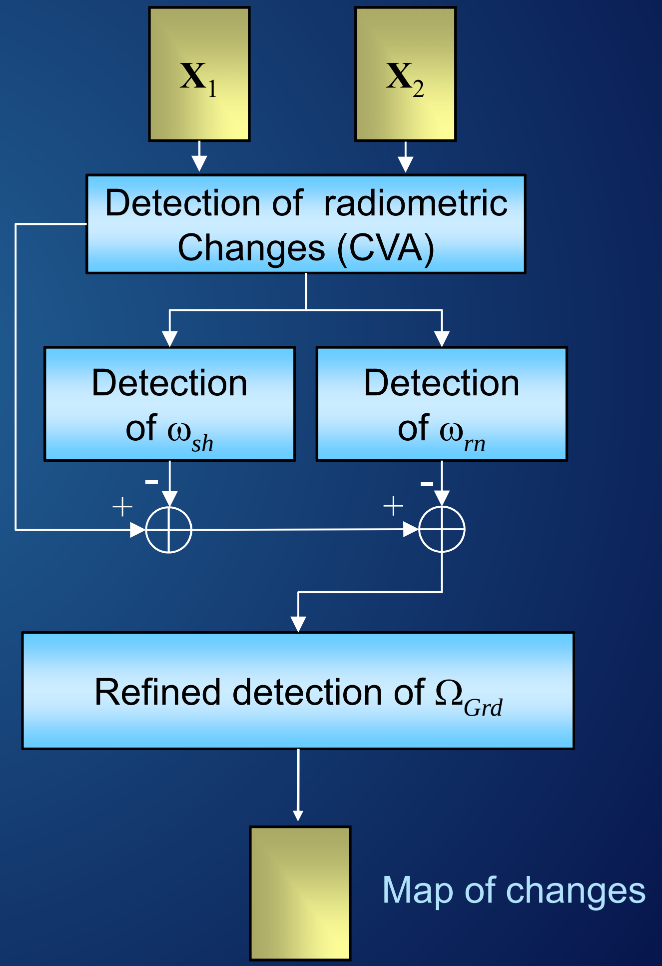


Change Tree and Detection Strategy

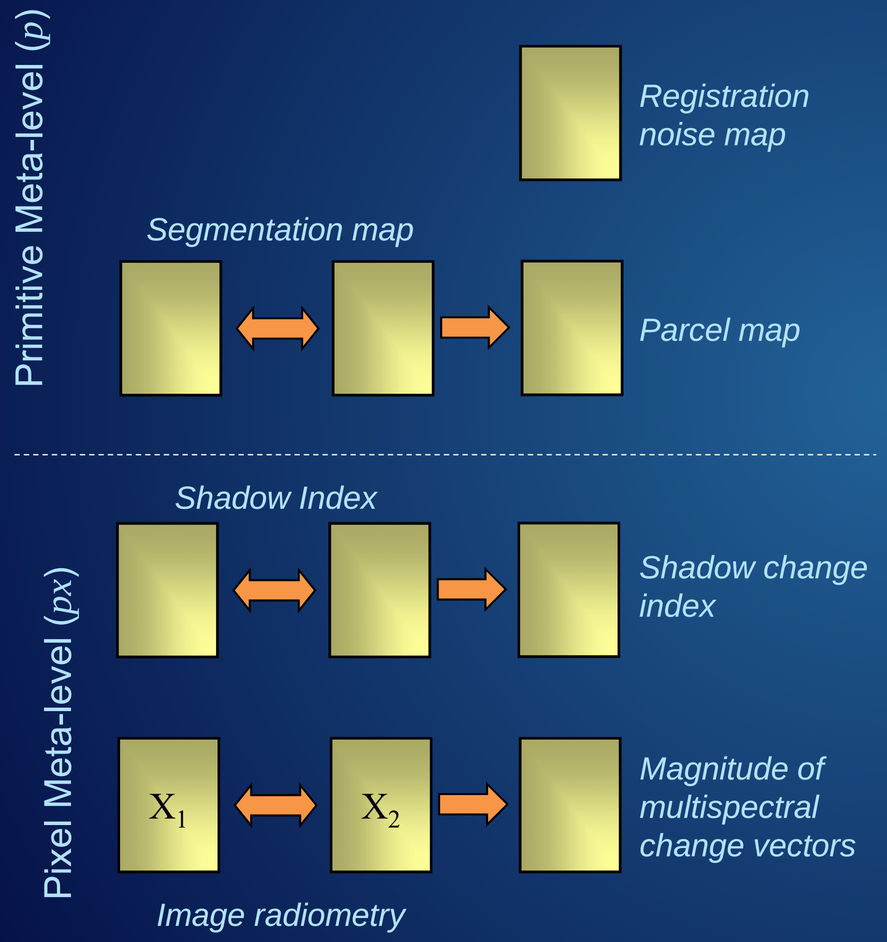
Identification of the tree of radiometric changes



Differential detection by cancellation



Multilevel Representation of Radiometric Changes



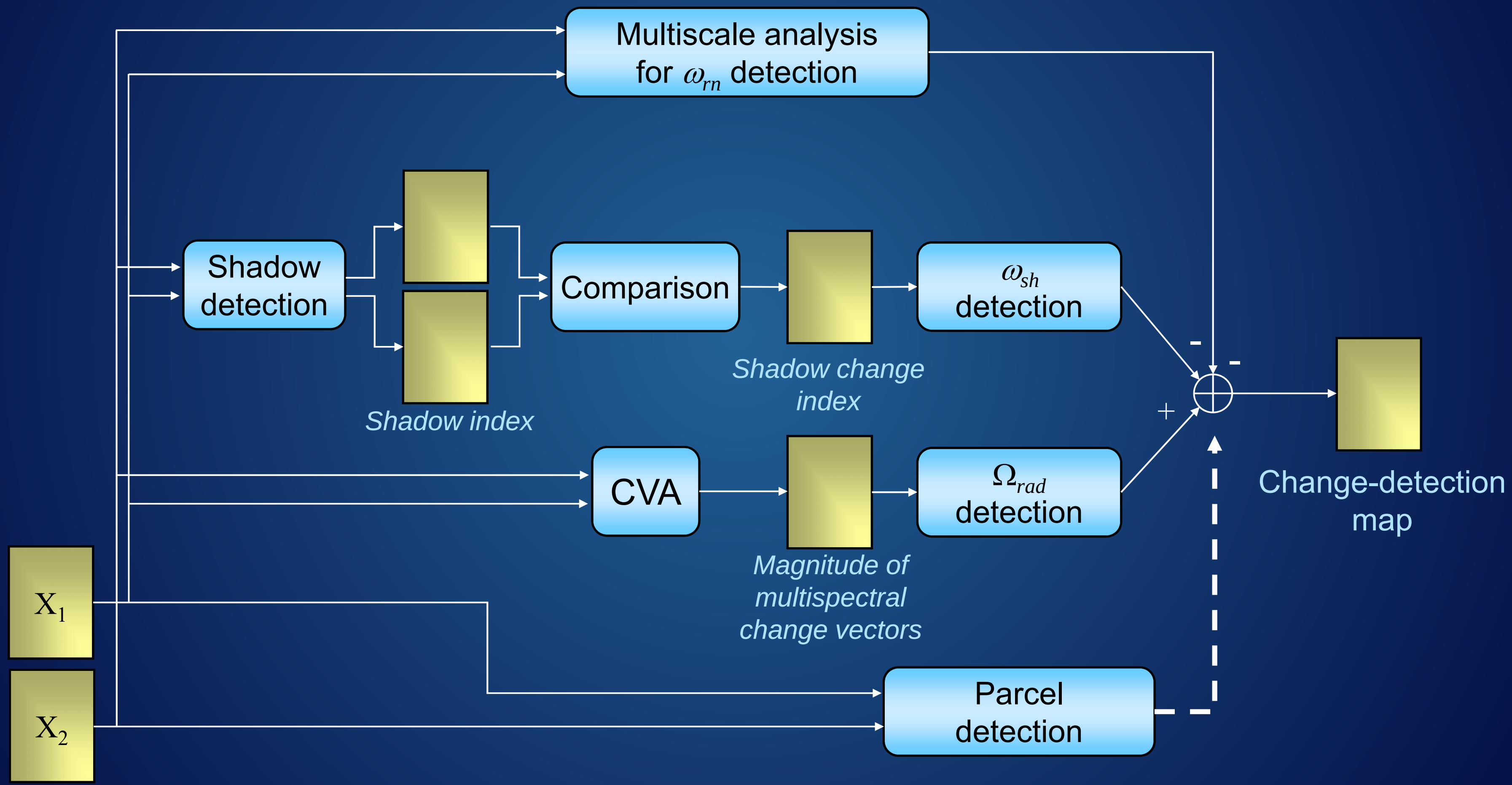
S. Marchesi, F. Bovolo, L. Bruzzone, "A Context-Sensitive Technique Robust to Registration Noise for Change Detection in VHR Multispectral Images", *IEEE Transactions on Image Processing*, Vol. 19, pp. 1877-1889, 2010.

F. Bovolo, "A Multilevel Parcel-Based Approach to Change Detection in Very High Resolution Multitemporal Images," *IEEE Geoscience and Remote Sensing Letters*, Vol. 6, No. 1, pp. 33-37, January 2009.

V. J. D. Tsai, "A comparative study on shadow compensation of color aerial images in invariant color models," *IEEE Trans. Geosci. Remote Sens.*, vol. 44, pp. 1661-1671, 2006.

L. Bruzzone and D. Fernández-Prieto, "Automatic Analysis of the Difference Image for Unsupervised Change detection," *IEEE Trans. Geosci. Rem. Sens.*, vol. 38, pp. 1170-1182, 2000.

Example: CD Architecture

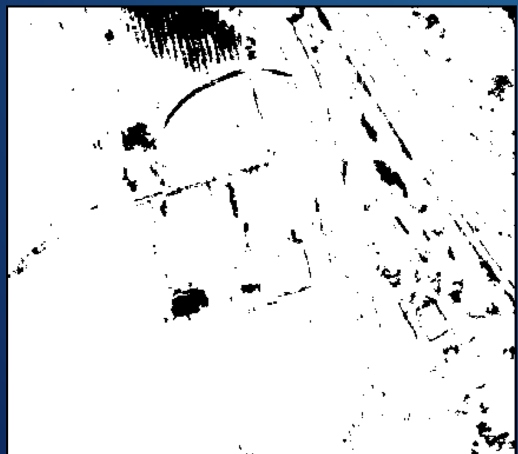


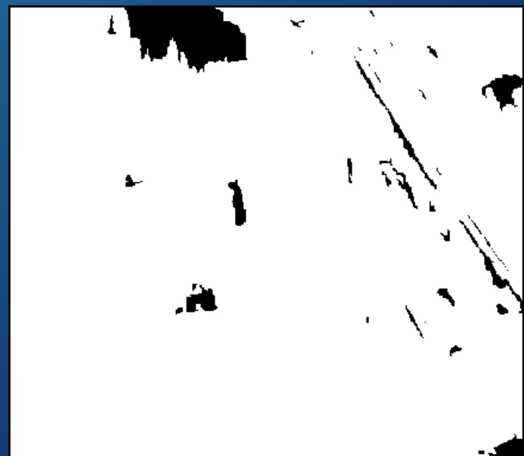
Example: Qualitative Results


October 2005

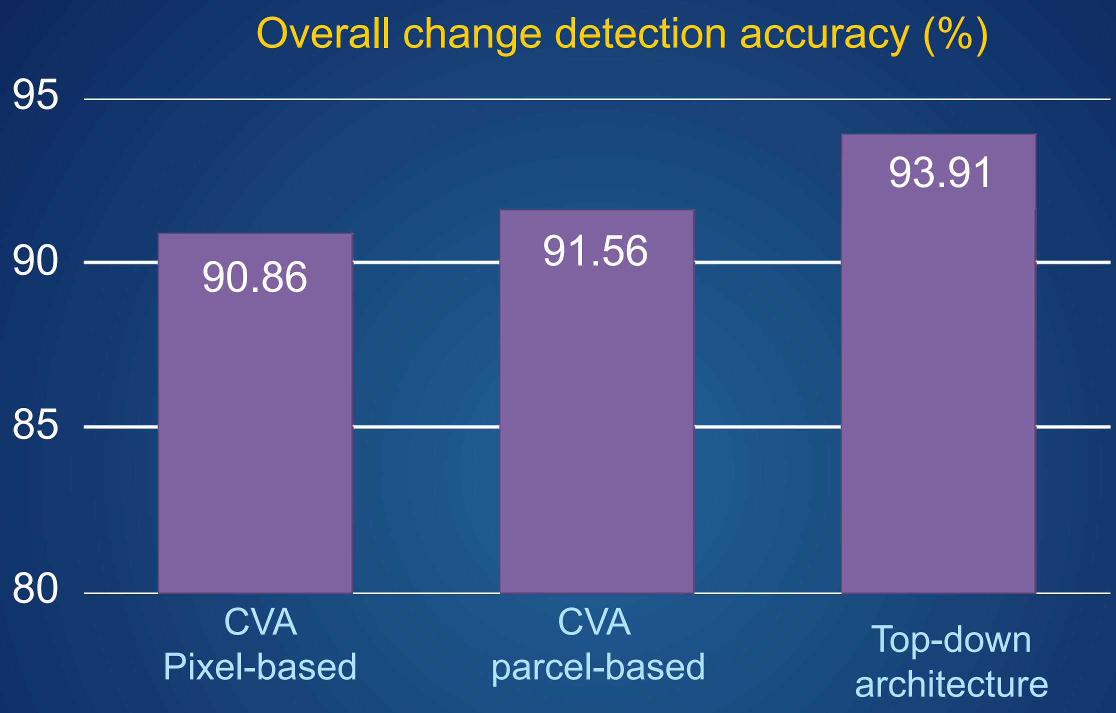

July 2006


Reference Map


Change Detection Map
CVA Parcel Based


Change detection Map
Top-down Architecture

Example: Quantitative Results



Technique	False Alarms	Missed Alarms	Total Errors	Overall accuracy (%)
CVA pixel-based	5005	9924	14929	90.86
CVA parcel-based	3537	10261	13798	91.56
Top-down architecture	1470	8480	9950	93.91

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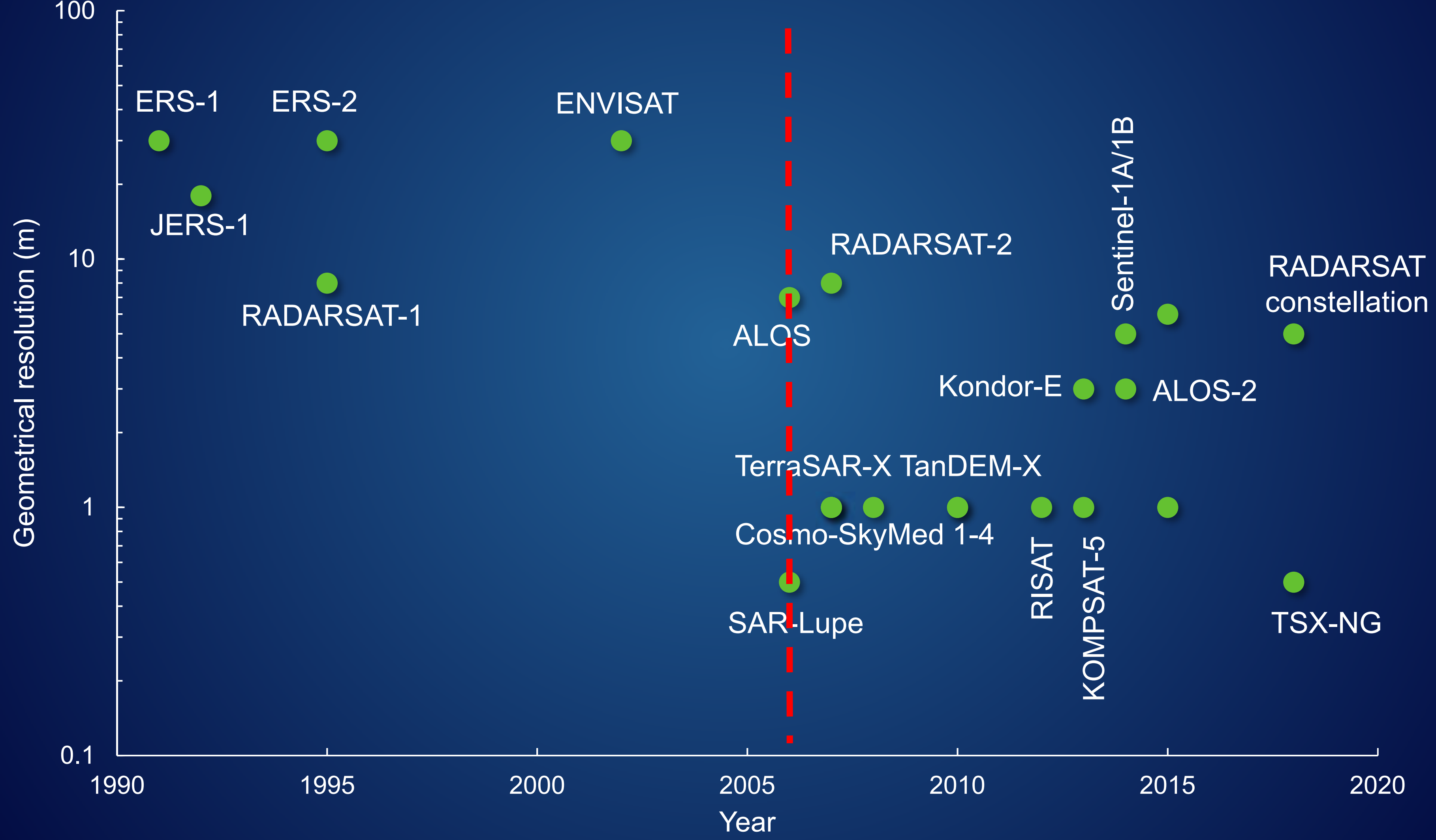
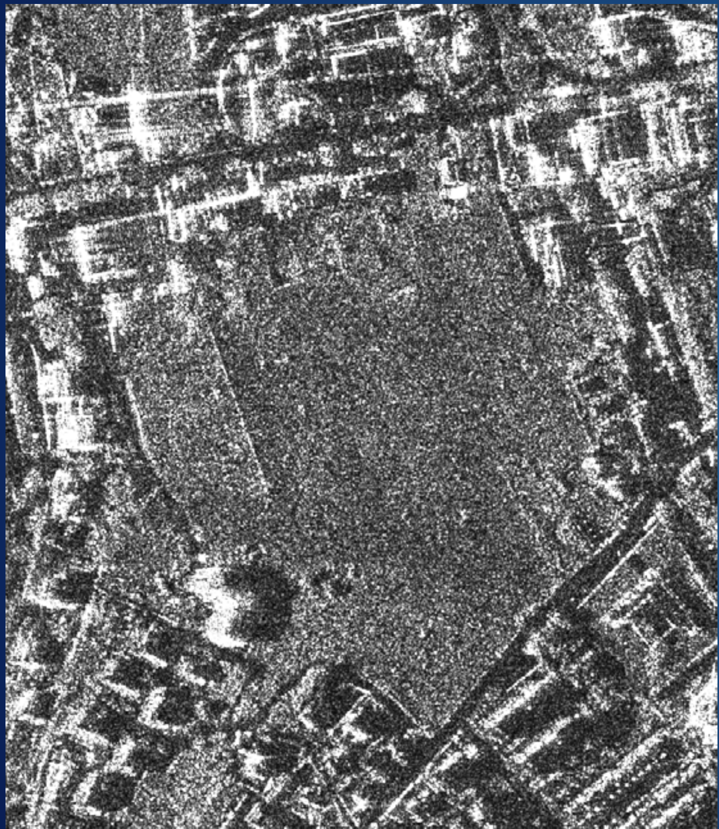
3. Change Detection in Very High Resolution SAR Images

New Satellites with VHR SAR Sensors



Multitemporal SAR Images: New Challenges

April 2009



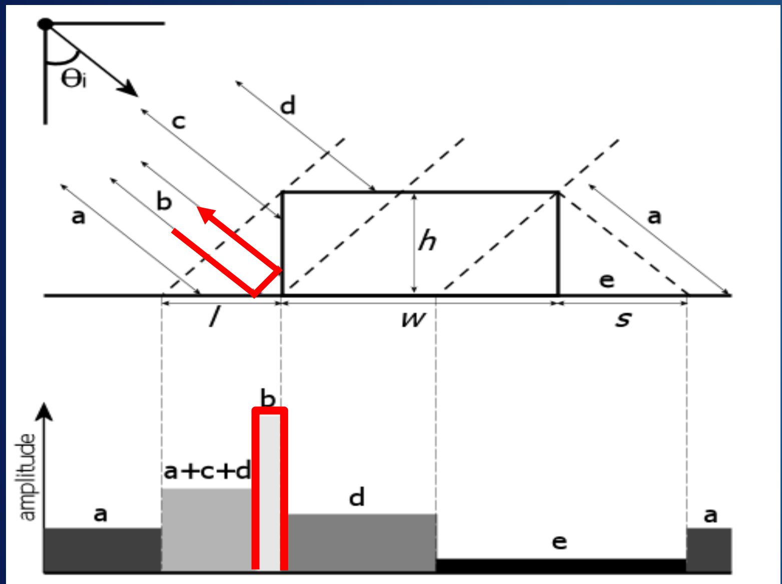
September 2009

Comso-Skymed SAR Images of the Earthquake of L'Aquila, Italy

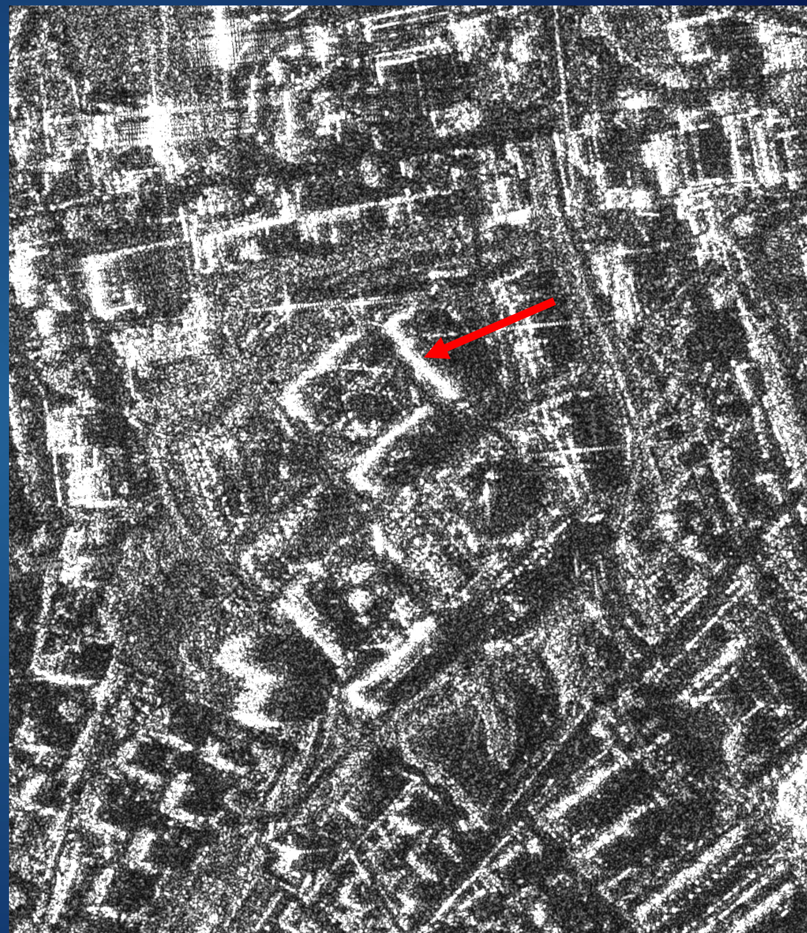
CD in VHR SAR Images

- ✓ In multitemporal SAR VHR images we have many sources of backscattering changes.
- ✓ Often backscattering changes associated with different sources exhibit characteristics similar to each other. They can be separated only by explicitly modeling the EM behavior of complex objects.
- ✓ To this end it is necessary to bridge the semantic gap between low level features and semantic information:
  - Modelling the interaction between the EM waves and the imaged objects;
  - Extracting the different object components with proper detectors;
  - Combining object components for identifying the objects and the possible changes in their state.

Example: Building Detection in VHR SAR Images



Building EM model



VHR satellite SAR image

Change Detection in VHR SAR Images

- Moving from object detection in single images to object change detection in multitemporal images increases the complexity of the information extraction.

- In order to define an effective general approach to change detection for VHR SAR images we have to:

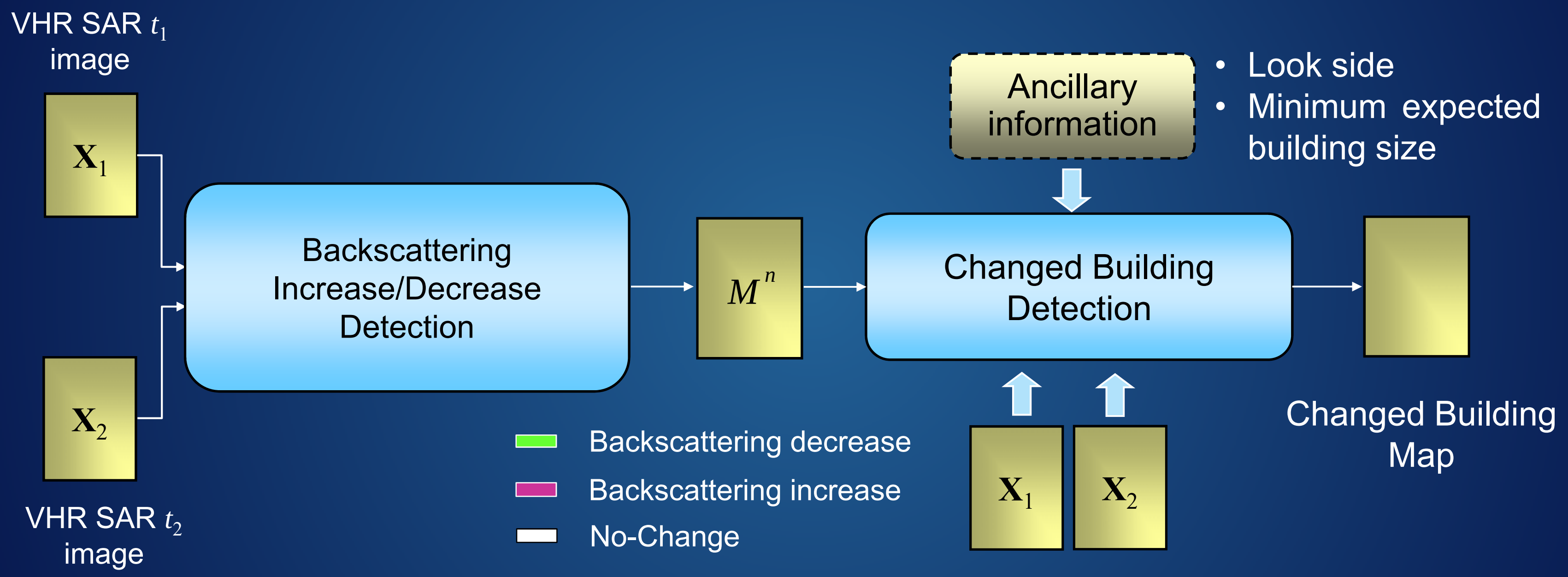
  ✓ Decompose the general complex problem in simpler hierarchical problems.

  ✓ Exploit the intrinsic multiscale nature of objects present in VHR images.

  ✓ Model the specific properties of expected changes for extracting the semantic meaning of backscattering changes.

  ✓ Exploit the available prior information on the considered scenario.

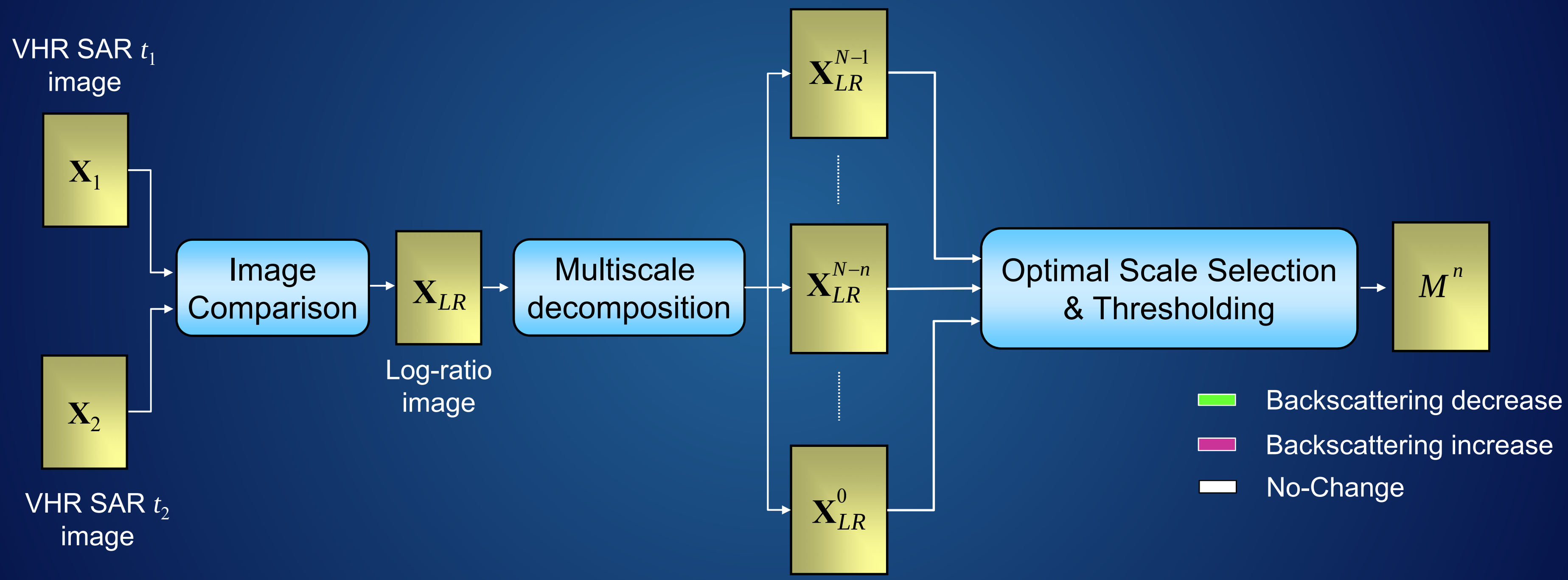
Architecture for Building Change Detection



F. Bovolo, C. Marin, L. Bruzzone, "A Hierarchical Approach to Change Detection in Very High Resolution SAR Images for Surveillance Applications," *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 51, pp. 2042-2054, 2013.

Architecture for Building Change Detection

Goal: detect changes associated with increase and decrease in backscattering.

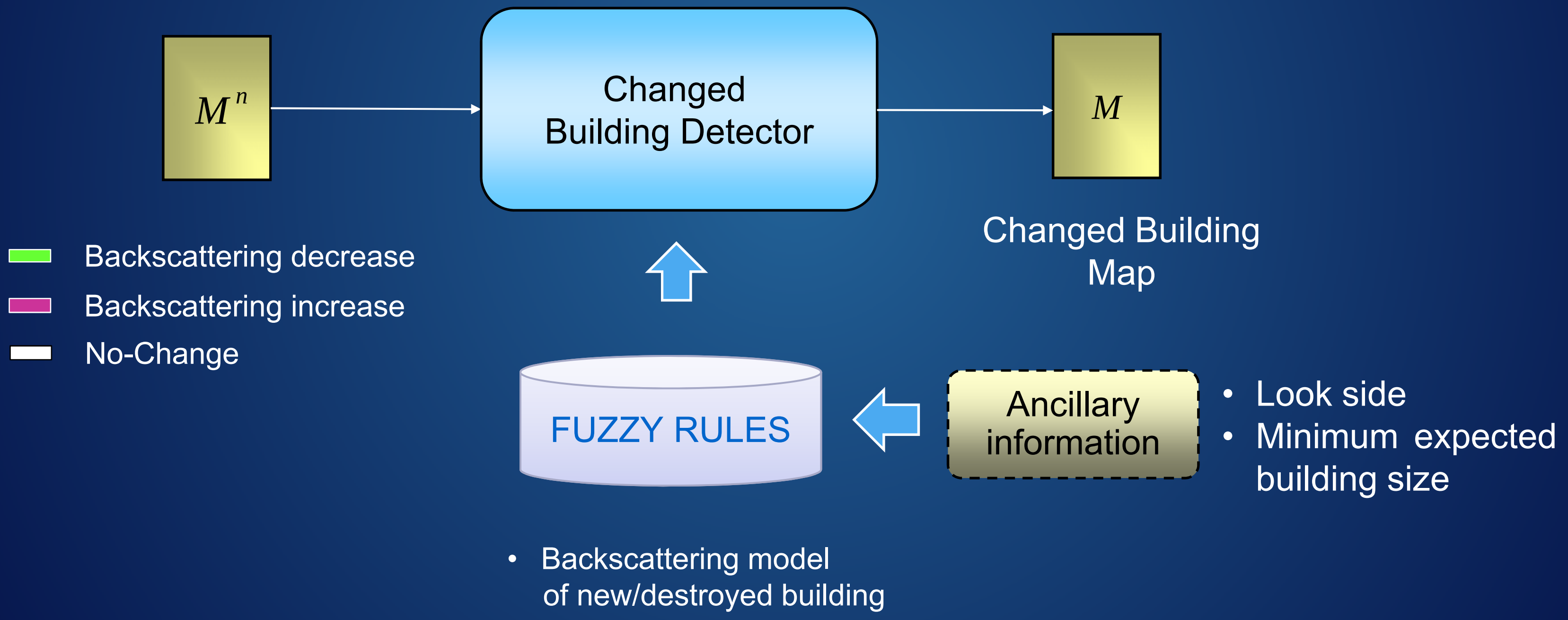


F. Bovolo, L. Bruzzone, "A Detail-Preserving Scale-Driven Approach to Unsupervised Change Detection in Multitemporal SAR Images", *IEEE Transactions on Geoscience and Remote Sensing*, 2005, Vol.43, No. 12, pp. 2963-2972, 2005.

F. Bovolo and L. Bruzzone, “A split-based approach to unsupervised change detection in large-size multitemporal images: Application to tsunami-damage assessment,” *IEEE Trans. Geosci. Rem. Sens*, vol. 45, no. 6, pp. 1658 –1670, 2007.

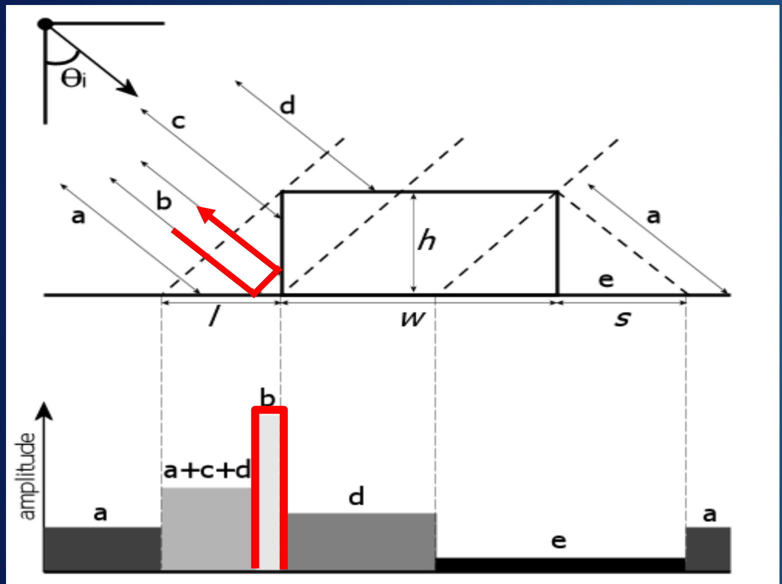
Architecture for Building Change Detection

Goal: detect new/destroyed buildings.



C. Marin, F. Bovolo, L. Bruzzone, Building Change Detection in Multitemporal Very High Resolution SAR Images, *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 53, 2015, pp. 2664–2682.

Architecture for Building Change Detection



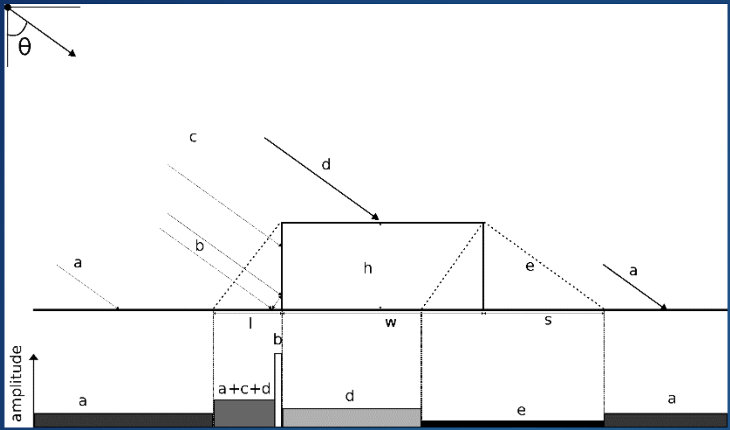
Building EM model

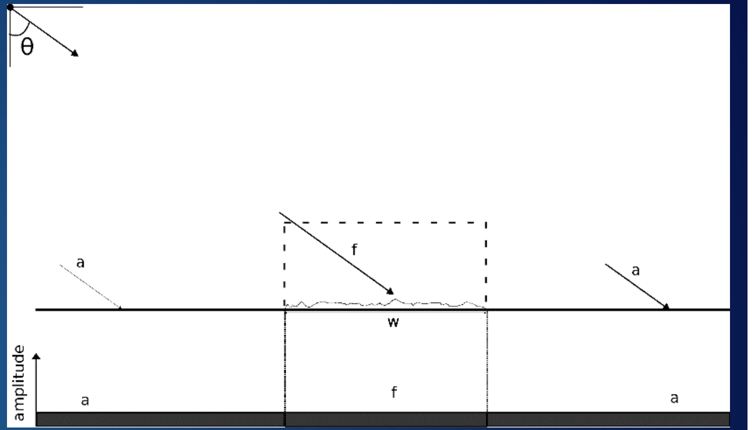
VHR satellite SAR image

Architecture for Building Change Detection

✓ Scattering models for flat-roof buildings [8] and bare land.

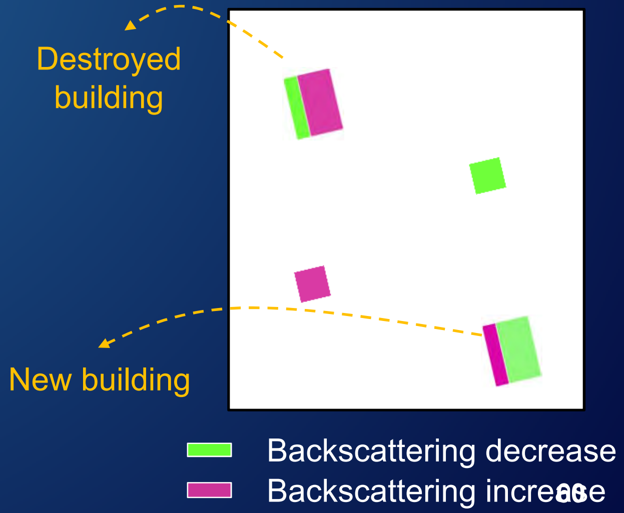
a) Ground return;
b) Double bounce;
c) Building wall;
d) Building roof;
e) Shadow;
a+c+d) Layover;
f) Bare soil.





✓ Changes in VHR SAR images imply increase or decrease of backscattering values.

✓ Changes in buildings (i.e., new/destroyed buildings) imply the generation of patterns of increase/decrease with specific proprieties.

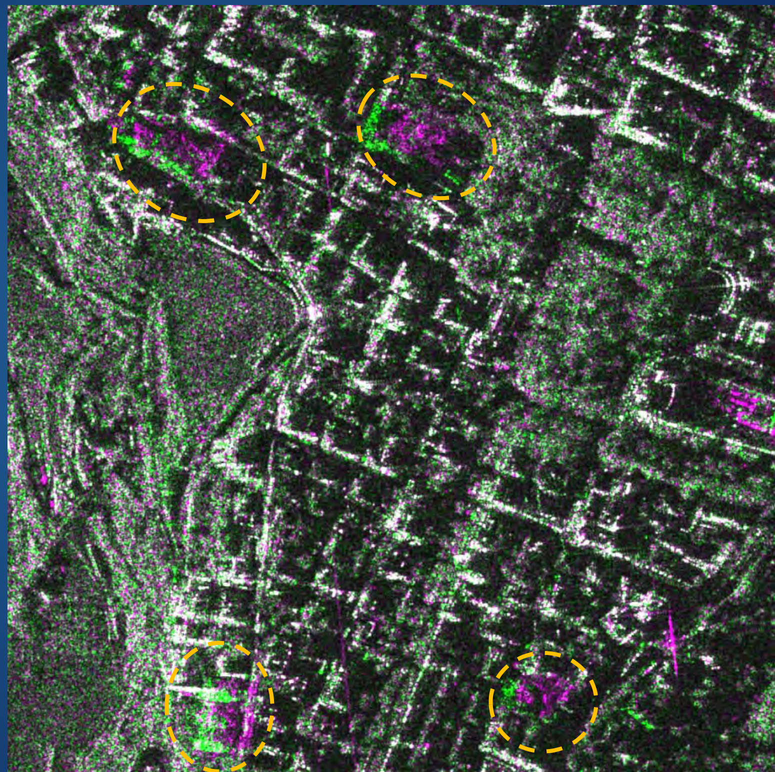


Example: L'Aquila Earthquake

Multitemporal data set: SpotLight (CSK®) images acquired before (5th April 2009) and after (21st April 2009) the earthquake of L'Aquila (Italy, 6th April 2009).

Optical image GeoEye, Tele Atlas 2011
Google ©

5th April 2009



RGB multitemporal composition
(R:04/21/2009, G:04/05/2009, B:04/21/2009)

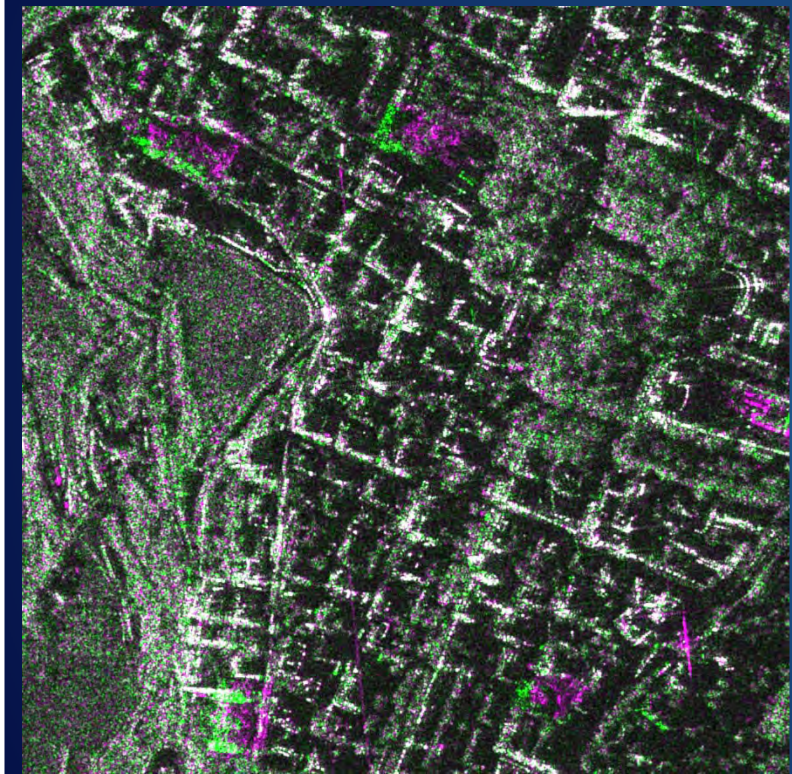
21st April 2009

- 1m×1m resolution
- X-band
- 1-look
- Amplitude
- HH-polarization
- 57-58 degree incidence angle
- Ascending orbit
- Right look
- CSKS1
- Calibrated
- Co-registered
- Geo-referred

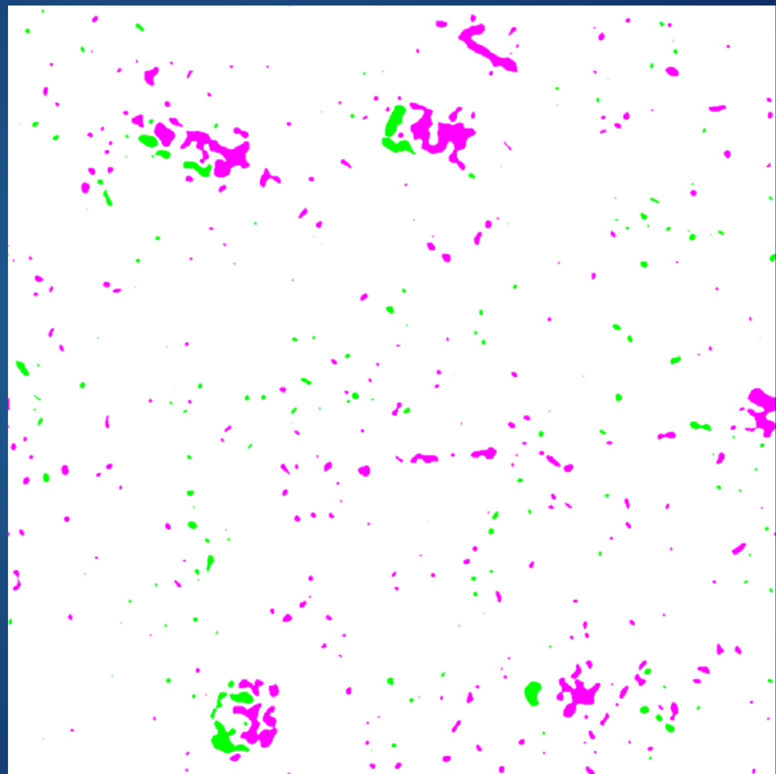
Backscattering decrease   Backscattering increase   Unchanged areas

Example: L'Aquila Earthquake

Detection of increase and decrease of backscattering performed by using stationary wavelet transform applied to the log-ratio image.



RGB multitemporal composition
(R:09/12/2009, G:04/05/2009, B:09/12/2009)



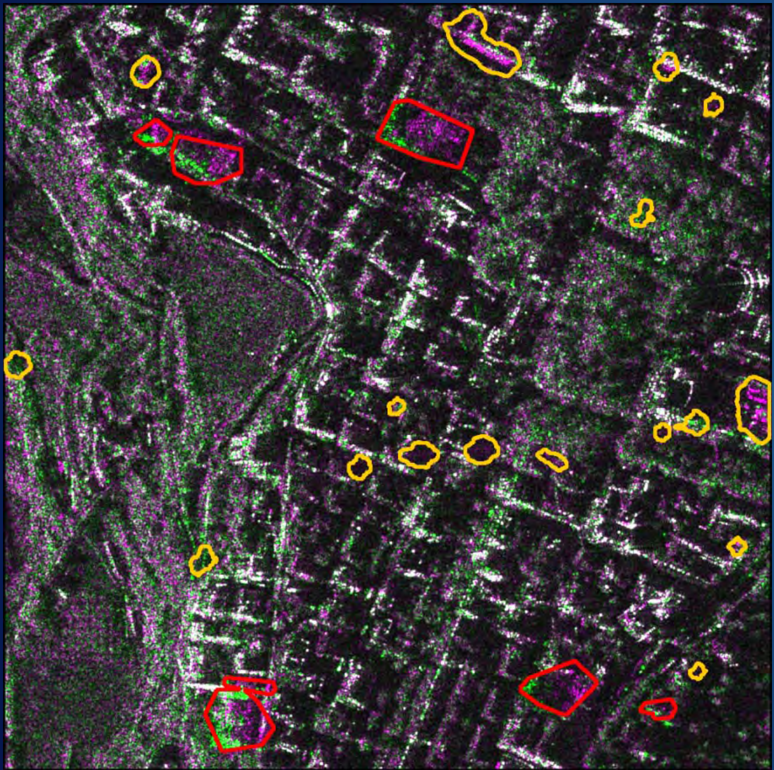
M_{SL}

- 1m×1m resolution
- X-band
- 1-look
- Amplitude
- HH-polarization
- 57-58 degree incidence angle
- Ascending orbit
- Right look
- CSKS1
- Calibrated
- Co-registered
- Geo-referred

Backscattering decrease · Backscattering increase · Unchanged areas

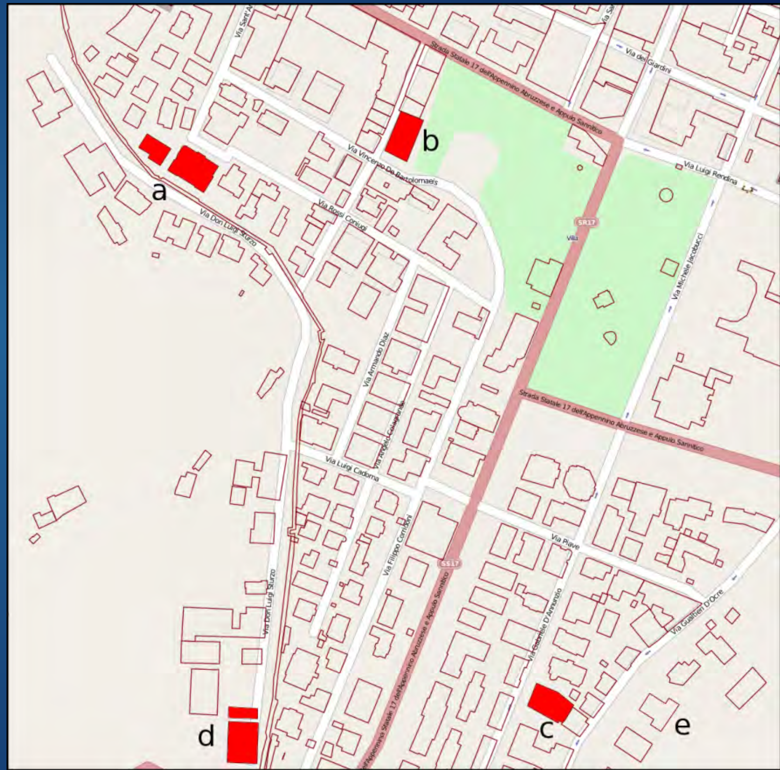
Example: L'Aquila Earthquake

Generation of the building change detection according to the output of fuzzy rules.



Overlay between RGB and the final buildings change detection map

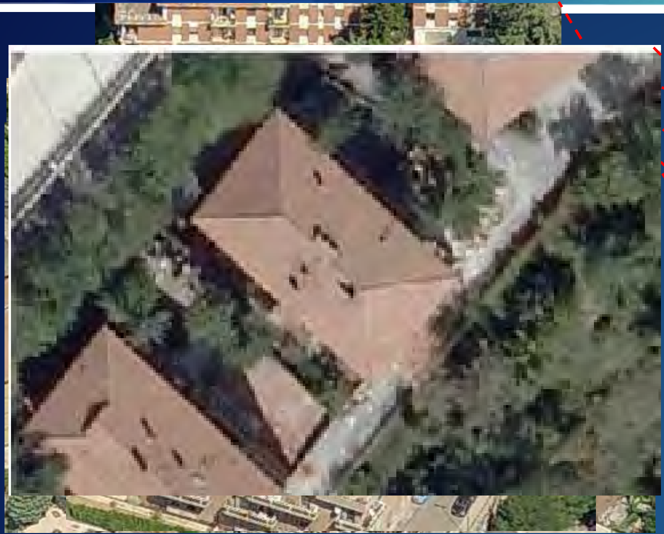
Collapsed buildings   Other changes



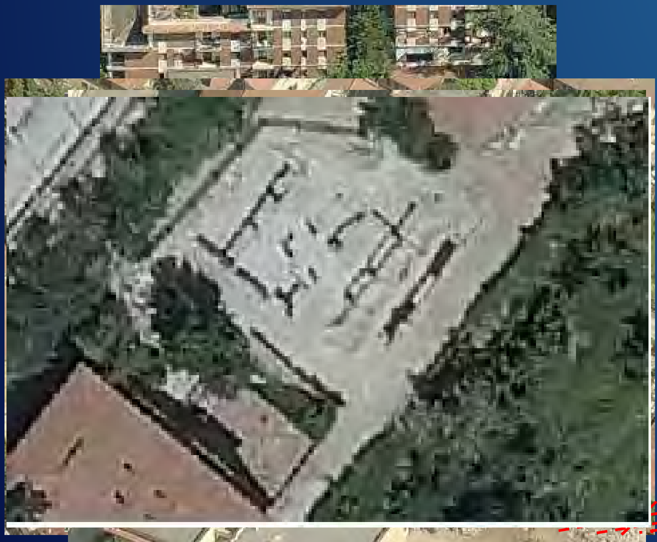
Ground Truth from orthophotos acquired on April 2009 by the civil protection (GeoPortale Abruzzo)

Example: L'Aquila Earthquake

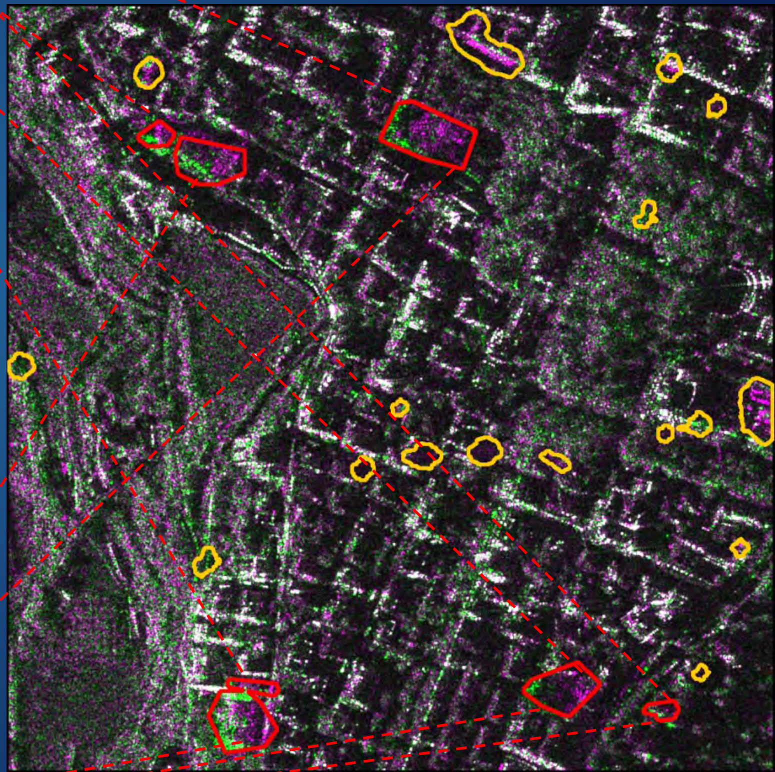
Optical image Pictometry International Corp © Microsoft Corporation ©



Pre-Crisis Reference Image



Post-Crisis Reference Image

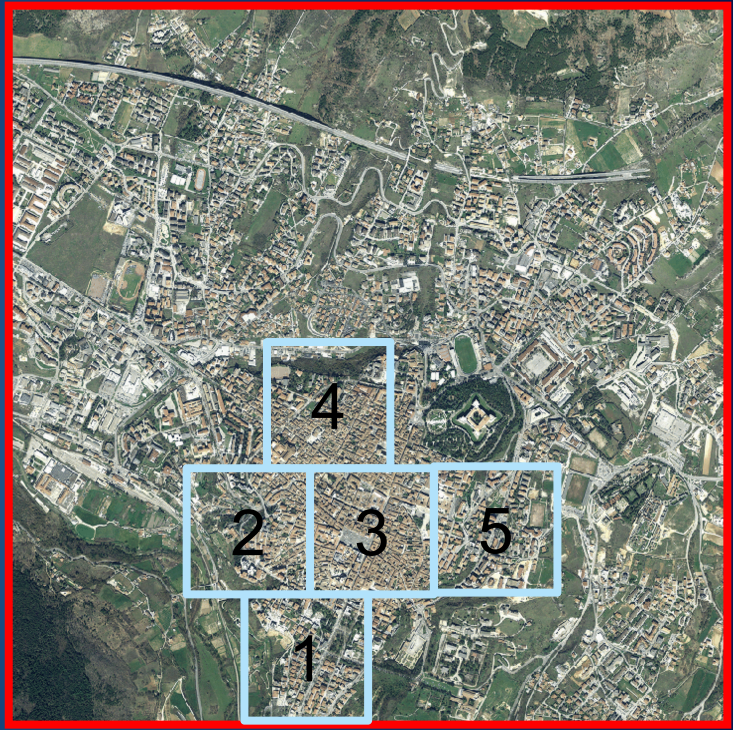


Changed building map

Destroyed Building Other Changes)

Example: L'Aquila Earthquake

Area	Total # of buildings	Actually destroyed	Missed	False
1	200	7	0	0
2	200	6	2	0
3	400	2	1	1
4	400	0	0	1
5	200	0	0	0
Total	1400	15	3	2



Reference about collapsed buildings derived from airborne orthophotos acquired after the earthquake available at www.regione.abruzzo.it/xcartografia/.

C. Marin, F. Bovolo, L. Bruzzone, Building Change Detection in Multitemporal Very High Resolution SAR Images, *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 53, 2015, pp. 2664–2682.

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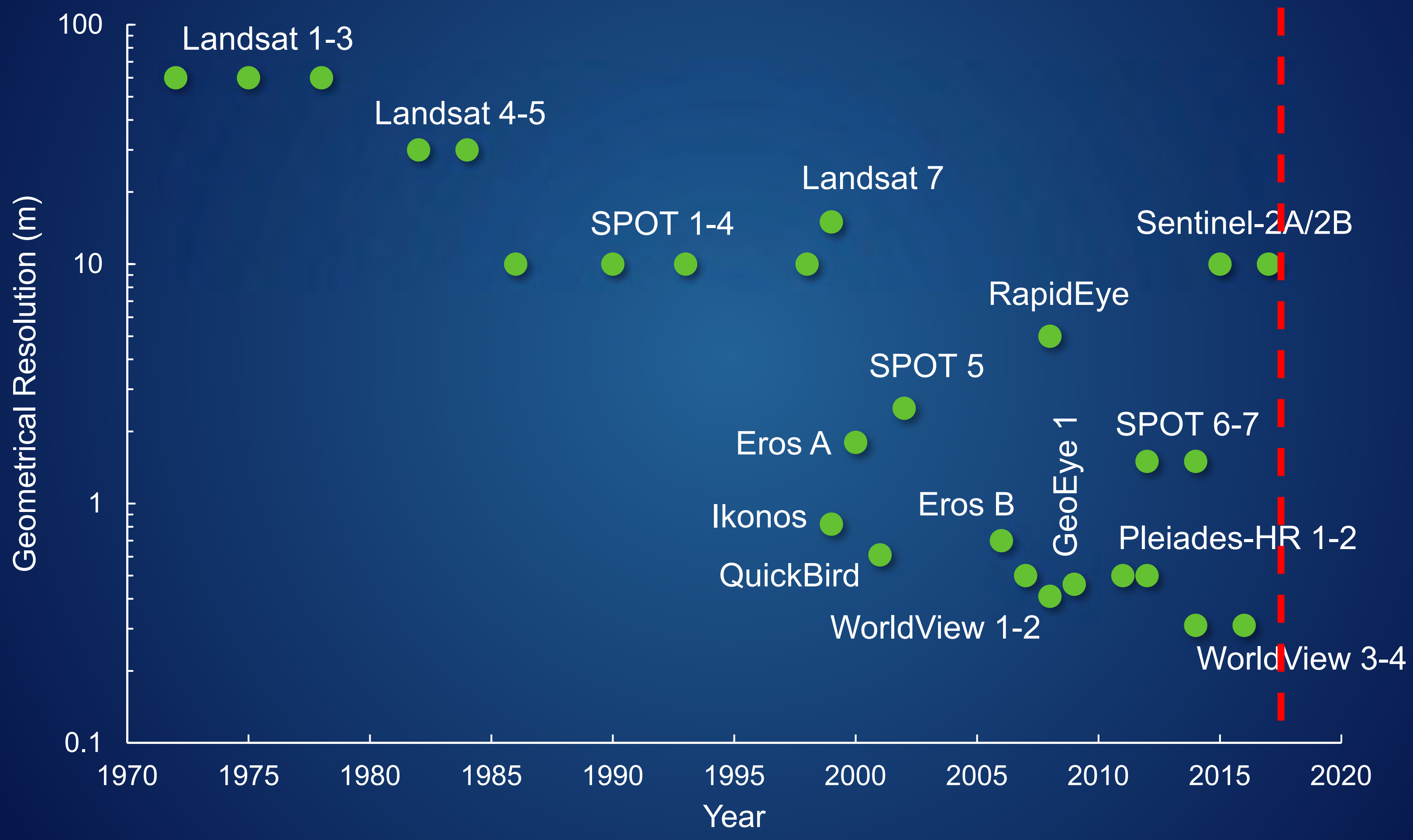
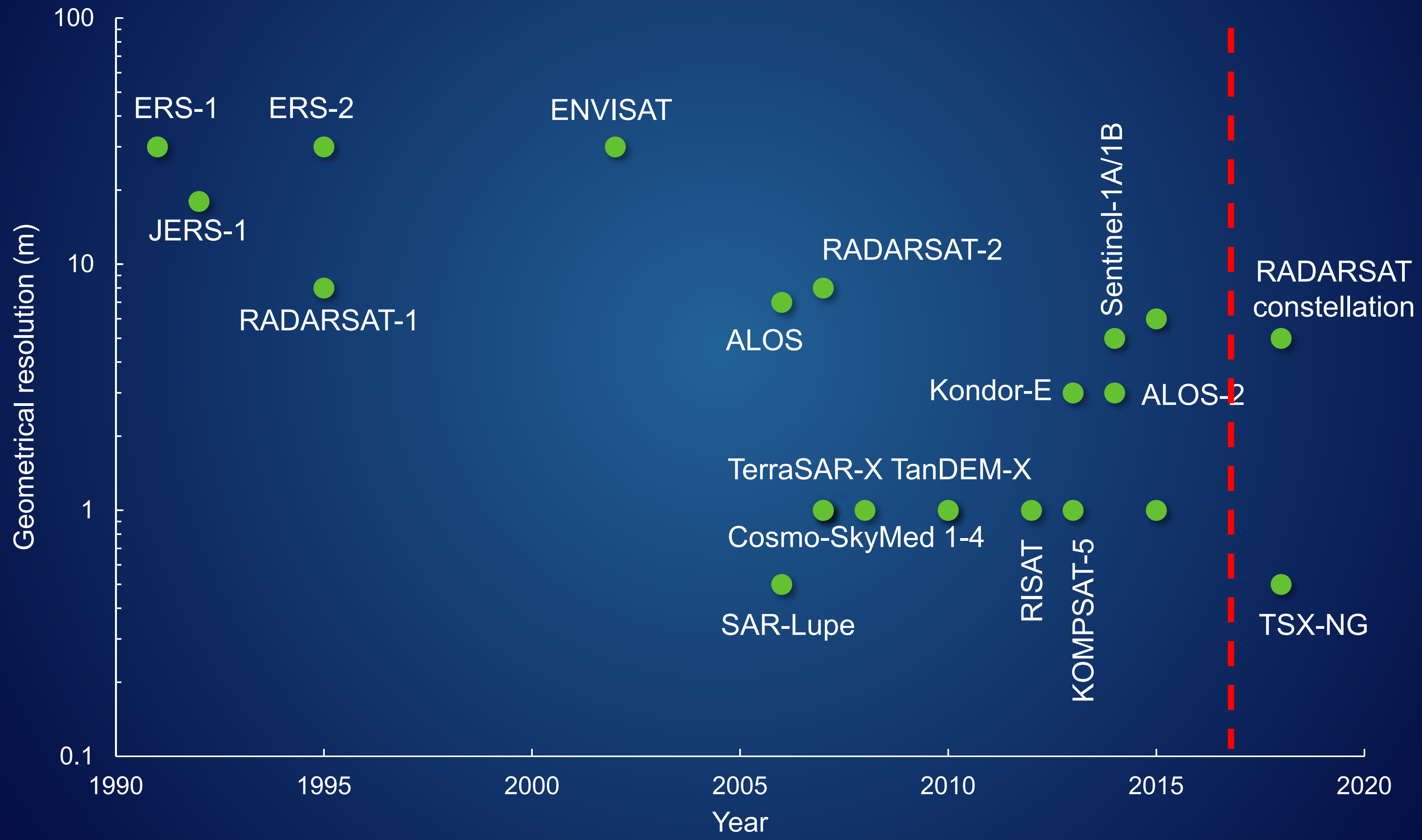
4. New Challenges in Multitemporal Data Analysis

Optical Satellite Missions

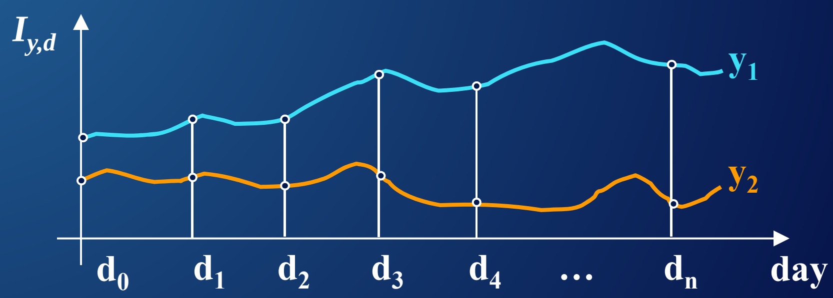


SAR Satellite Missions



Sentinel "Era"

- ✓ Exploit the large amount of freely available image time series of Sentinel and Landsat data for information extraction:
  - ✓ New paradigms for analysis of long time series of high resolution images;
  - ✓ New products at improved resolution;
  - ✓ New applications of the analysis of images time series.

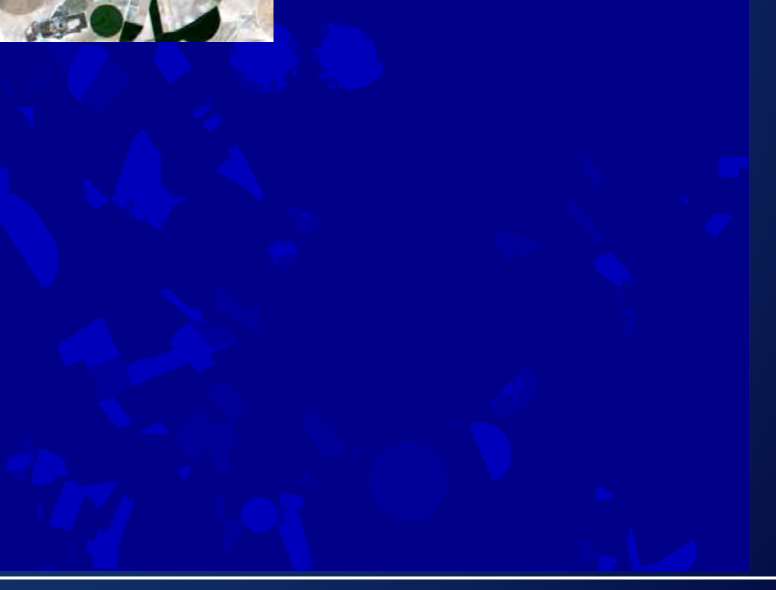


Example: Sentinel 2 Time Series

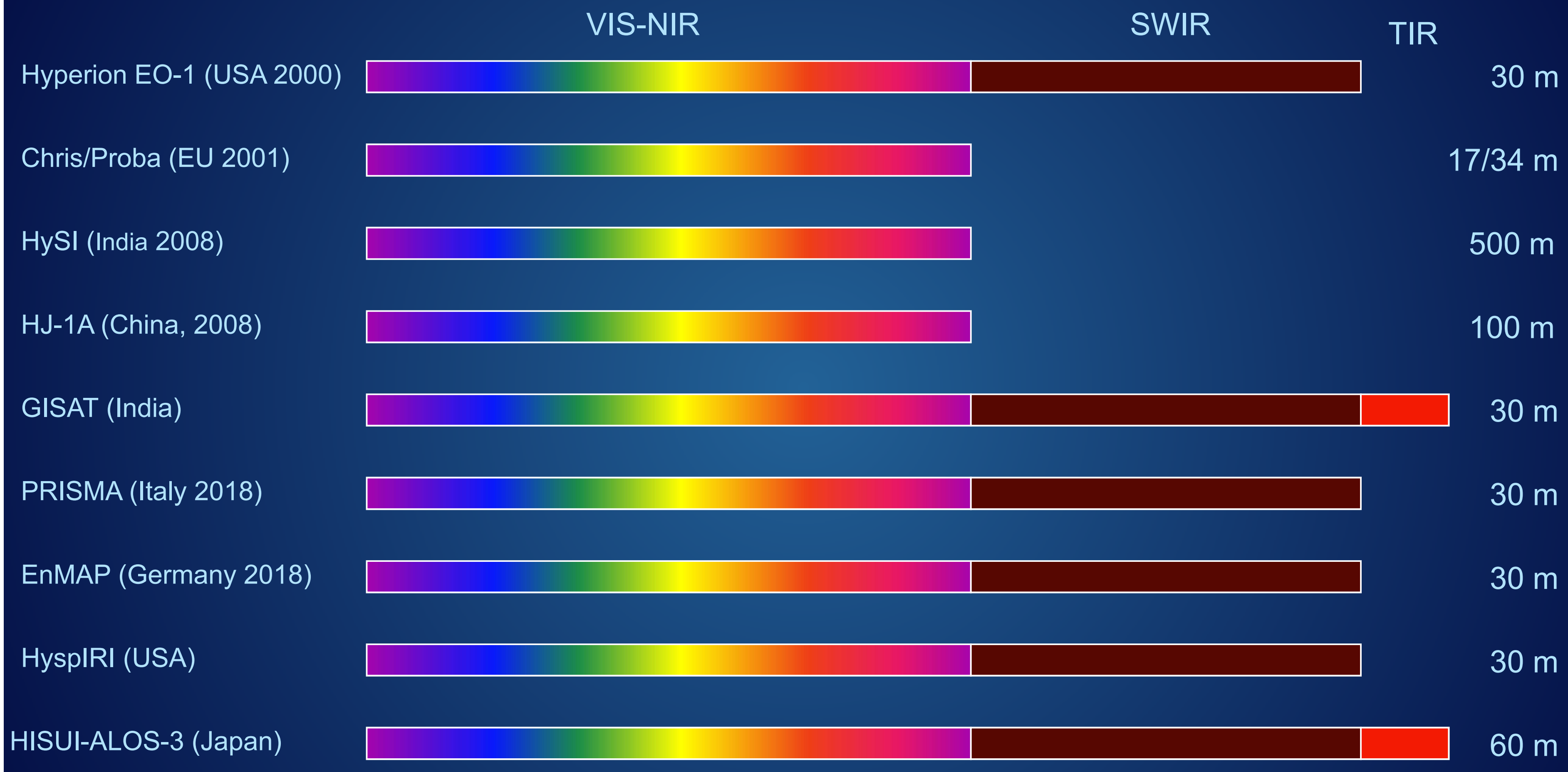
Barrax (Spain) Sentinel 2 Image Time Series

Cumulative Vegetation Index

Cumulative Water Index



Hyperspectral Systems

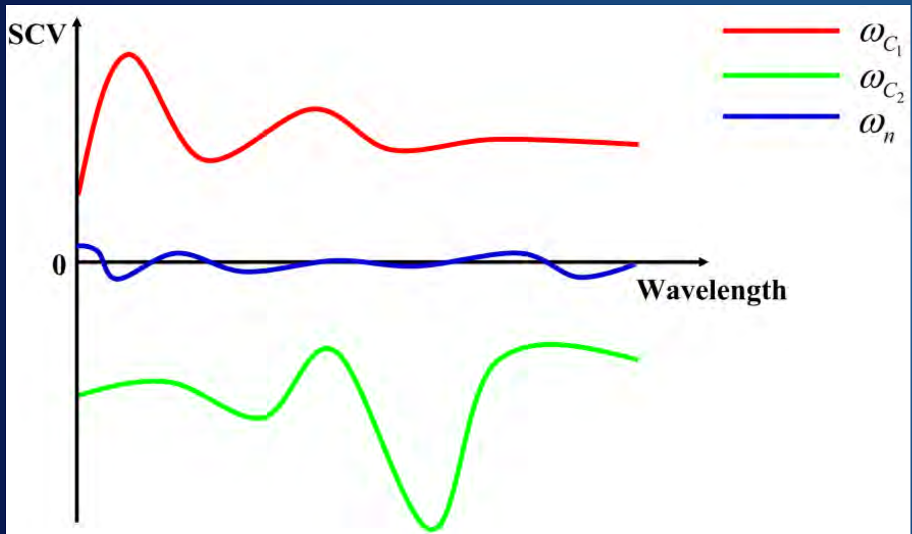


Source of data: IEEE GRSS ISIS Technical Committee

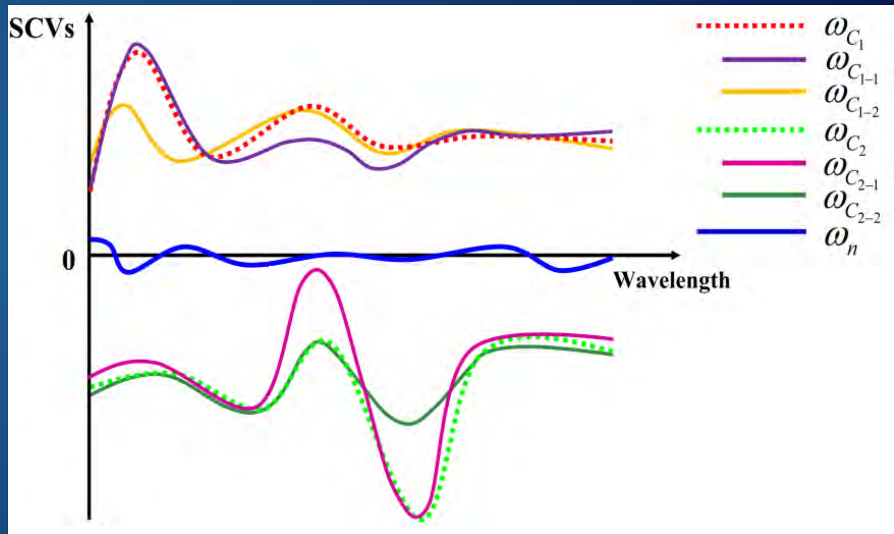
Change Detection in Hyperspectral Images

- ✓ Problem: what is a change in multitemporal hyperspectral images?
- ✓ Let us analyze the qualitative behaviors of an hyperspectral difference image:

Major changes



Subtle changes



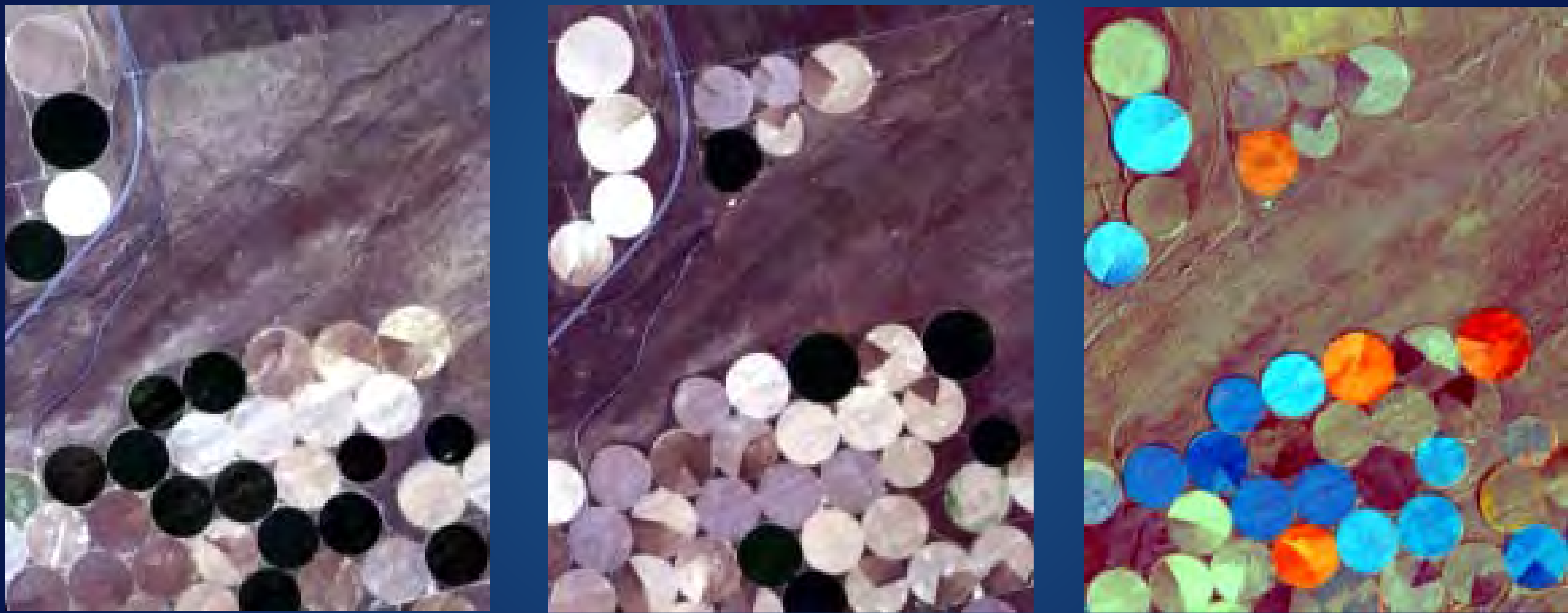
S. Liu, L. Bruzzone, F. Bovolo, P. Du, "Hierarchical Unsupervised Change Detection in Multitemporal Hyperspectral Images," IEEE Transactions on Geoscieance and Remote Sensing, Vol. 53, pp. 244 - 260, 2015.

S. Liu, L. Bruzzone, F. Bovolo, M. Zanetti, P. Du, "Sequential Spectral Change Vector Analysis for Change Detection in Multitemporal Hyperspectral Images," IEEE Transactions on Geoscience and Remote Sensing, Vol. 53, pp. 4363 – 4378, 2015.

S. Liu, L. Bruzzone, F. Bovolo, P. Du, "Unsupervised Multitemporal Spectral Unmixing for Detecting Multiple Changes in Hyperspectral Images," IEEE Transactions on Geoscience and Remote Sensing, Vol. 54, pp. 2733 - 2748, 2016.

Change Detection in Hyperspectral Images

Hyperspectral multitemporal images acquired by Hyperion in Oregon, USA



RGB composition of the t1 image RGB composition of the t2 image

(R: 650.67nm, G: 548.92nm, B: 447.17nm)

False color composition of the image difference (R: 1729.70nm, G: 1023.40nm, B: 752.43nm)

Change Detection in Hyperspectral Images

Hyperspectral multitemporal images acquired by Hyperion in Oregon, USA

False color composites of the difference image

R: 823.65nm
G: 721.90nm
B: 620.15nm

R:1729.7nm
G: 752.43nm
B: 548.92nm

Multiclass Change Detection map

Conclusion

- ✓ The current scenario is rich of opportunities:
  - ✓ Multitemporal VHR multispectral and SAR images;
  - ✓ Long time series of HR SAR and multispectral images;
  - ✓ Constellations of satellites with short revisit time;
  - ✓ Large archives of data available for free;
  - ✓ New data analysis paradigms (e.g., deep learning).

- ✓ Need to foster the development of methodologies, applications, and operational products related to mulitemporal data acquired by last generation satellite missions.

- ✓ Fundamental a cross disciplinary approach to the full exploitation of the potentialities of multitemporal data.

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