MedioGrid Platform and Applications

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Outline

- Objectives
- MedioGrid project
- MedioGrid infrastructure
- Satellite imagery oriented processing
- Diagrammatic process description - gProcess
- Application development
- Performance evaluation
- Conclusions

Research objectives

- Develop a research and academic Grid infrastructure
- Develop Grid based satellite imagery processing platform
- Develop environment oriented applications based on satellite imagery classification
- Services and Tools for Grid visualization
- Virtual geographical space modeling and visualization
- Performance evaluation

MedioGrid project

MedioGrid

Parallel and distributed graphical processing on Grid structure of geographical and environment data, 19CEEX-I03 (2005-2008)

The MEDIOGRID project aims to accomplish a pilot program to process the images acquired in real time from meteorological and resource satellites, in order to extract the meteorological and environment parameters that characterize the atmospheric and terrestrial state.

Project consortium:

1. Computer Science Department, Technical University of Cluj-Napoca, coordinator
2. Faculty of Geography, Babes Bolyai University, Cluj-Napoca
3. iQuest Company , Cluj-Napoca
4. National Administration of Meteorology, Bucharest
5. Computer Science Department, Politehnica University of Bucharest
6. Informatics Department, West University of Timisoara
7. Computer Science Department, Politehnica University of Timisoara

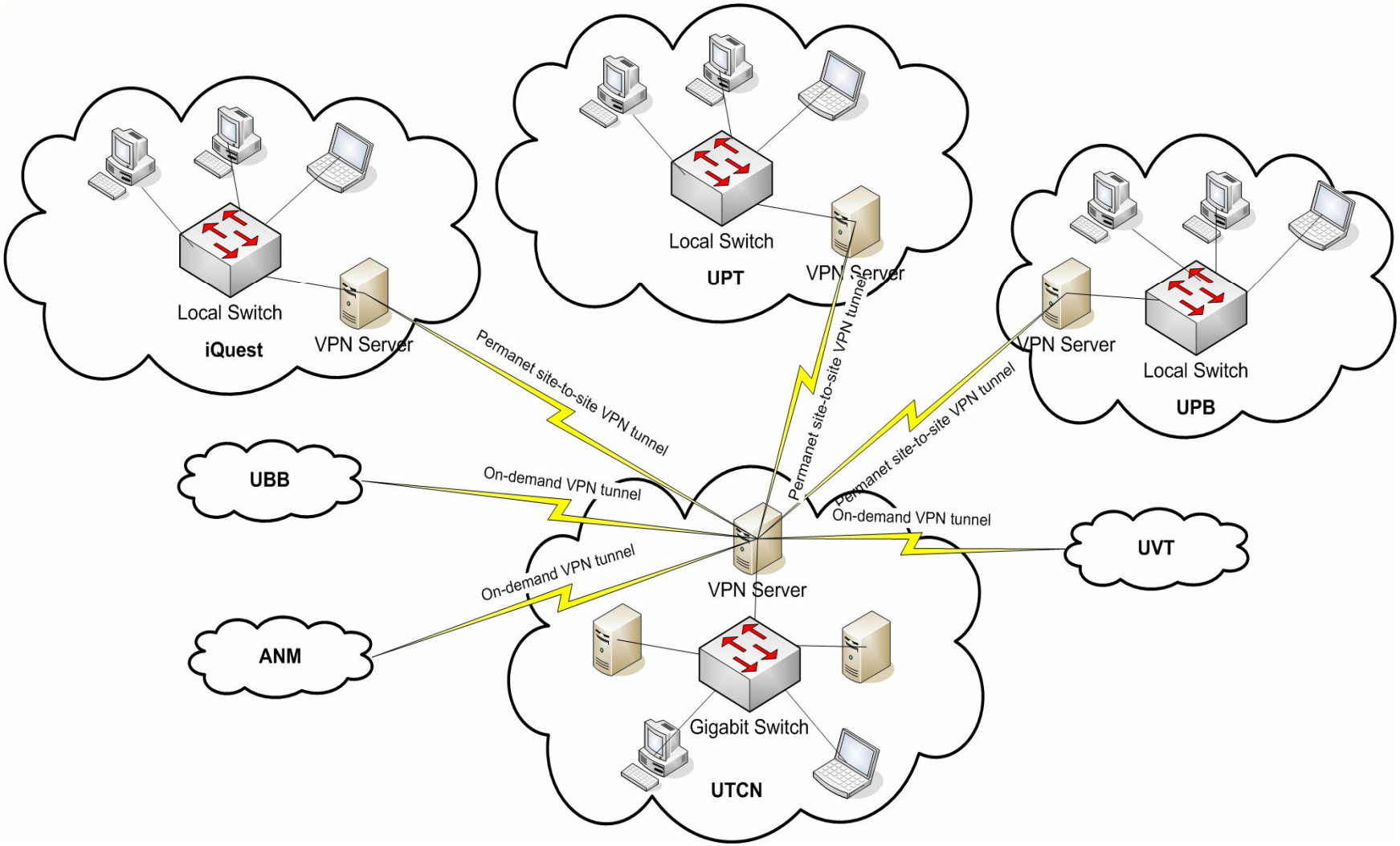
MedioGrid project

- Main objectives
  - Develop Grid structure to support the parallel and distributed processing of huge data (geographical and environmental)
  - Develop algorithms for Grid based processing of satellite images
  - Develop and experiment environment supervising applications with data extracted from satellite images
  - Model and visualize the virtual geographical space

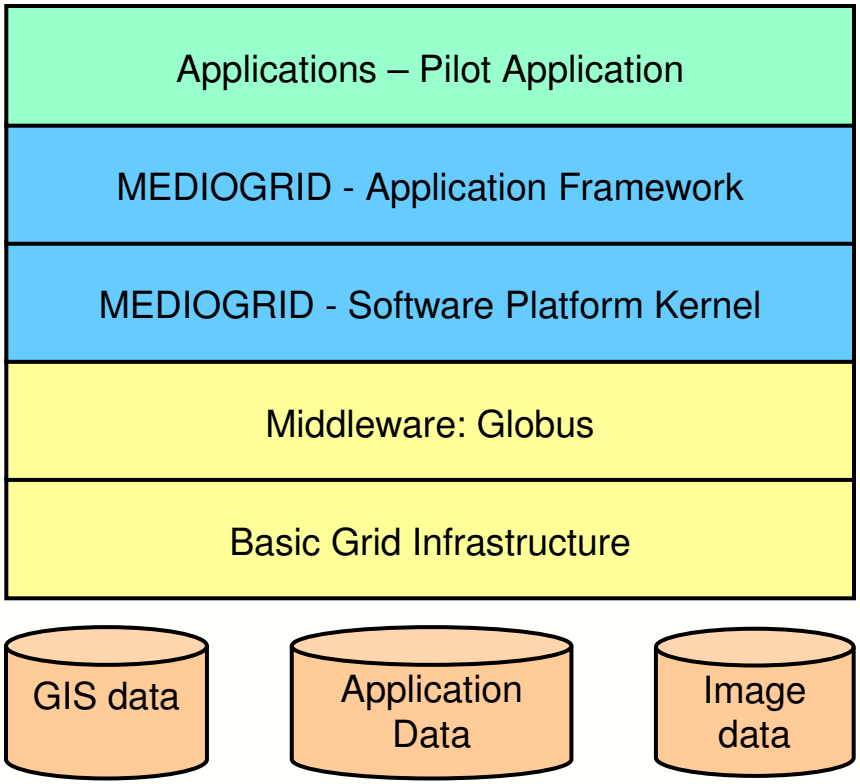
MedioGrid project' outcomes (2005-2008)

- Functional MedioGrid network (experimental Grid of 6 servers - Cluj, Timisoara, Bucharest and more than 100 workstations)
- Software applications: MedioGrid Software Platform Kernel, Image processing MODIS (NASA), Cloud detection, Vegetation classification (Greenland), Water detection (Waterland), Mineral area detection (Minerals)
- User interaction techniques for image based applications
- Diagrammatic Grid process description and scheduling for satellite image domain
- Grid and Web services based architecture
- Organize conferences and workshops: GridCAD (Timisoara 2007, 2006), ICCP-Grid Computing Workshop (Cluj-Napoca 2007), MedioGrid Workshop (Cluj-Napoca 2005)

MedioGrid architecture

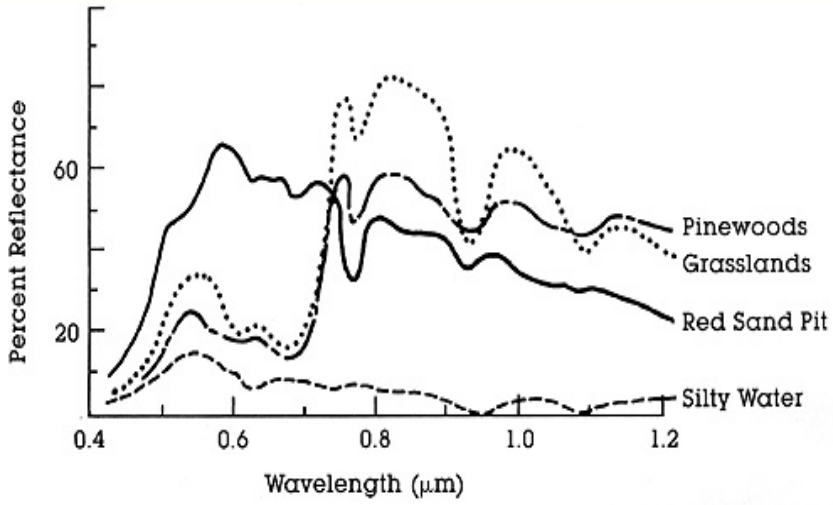


Functional MedioGrid layers



Satellite imagery oriented processing

- Satellite images: QuickBird, Ikonos, Modis, Aster, Landsat
- Spectral signature
- Vegetation indices based cover land classification, water detection, soil composition, cloud masks, change detection.



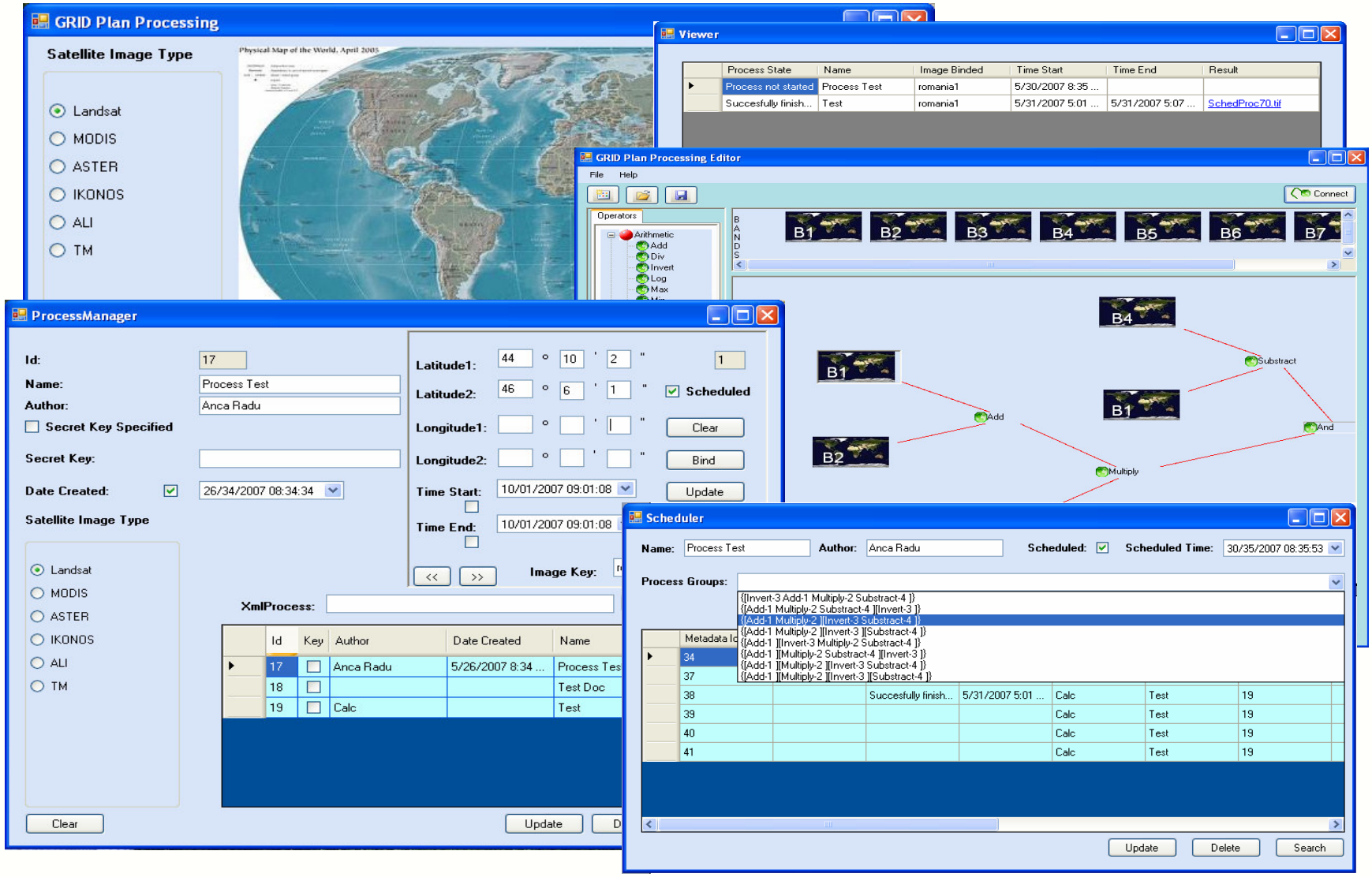
Data repository

- Satellite image
  - Landsat
    - Massive data. E.g. One image is about 600MB
    - Seven bands, 1-7
  - Modis
    - Produced by sensors onboard the Terra and Aqua satellites
    - Covers the entire surface of the Earth
    - 36 observational channels
    - 250m to 1km spatial resolution
    - Data distributed by the NASA DAAC
- Layered on eXist (XML database)
- OGSA-DAI technology

Landsat satellite images

- Massive data. E.g. One image is about 600MB
- seven bands 1-7
  - band 1 - water body penetration
  - band 2 - green reflectance of vegetation
  - band 3 - sensitive to chlorophyll absorption, determine the vegetation types
  - band 5 – information on vegetation and soil moisture
  - band 6 - vegetation stress
  - band 7 - discriminates the mineral and rock types
- Different information is highlighted by various band weighted combinations
  - bands 4, 3, and 2
    - Classify land water boundaries and different types of vegetation
  - bands 4 (NIR), 5 (SWIR), and 3 (RED)
    - Land/water boundaries and vegetation areas
    - Water detection

gProcess – Diagrammatic Process Description



gProcess architecture

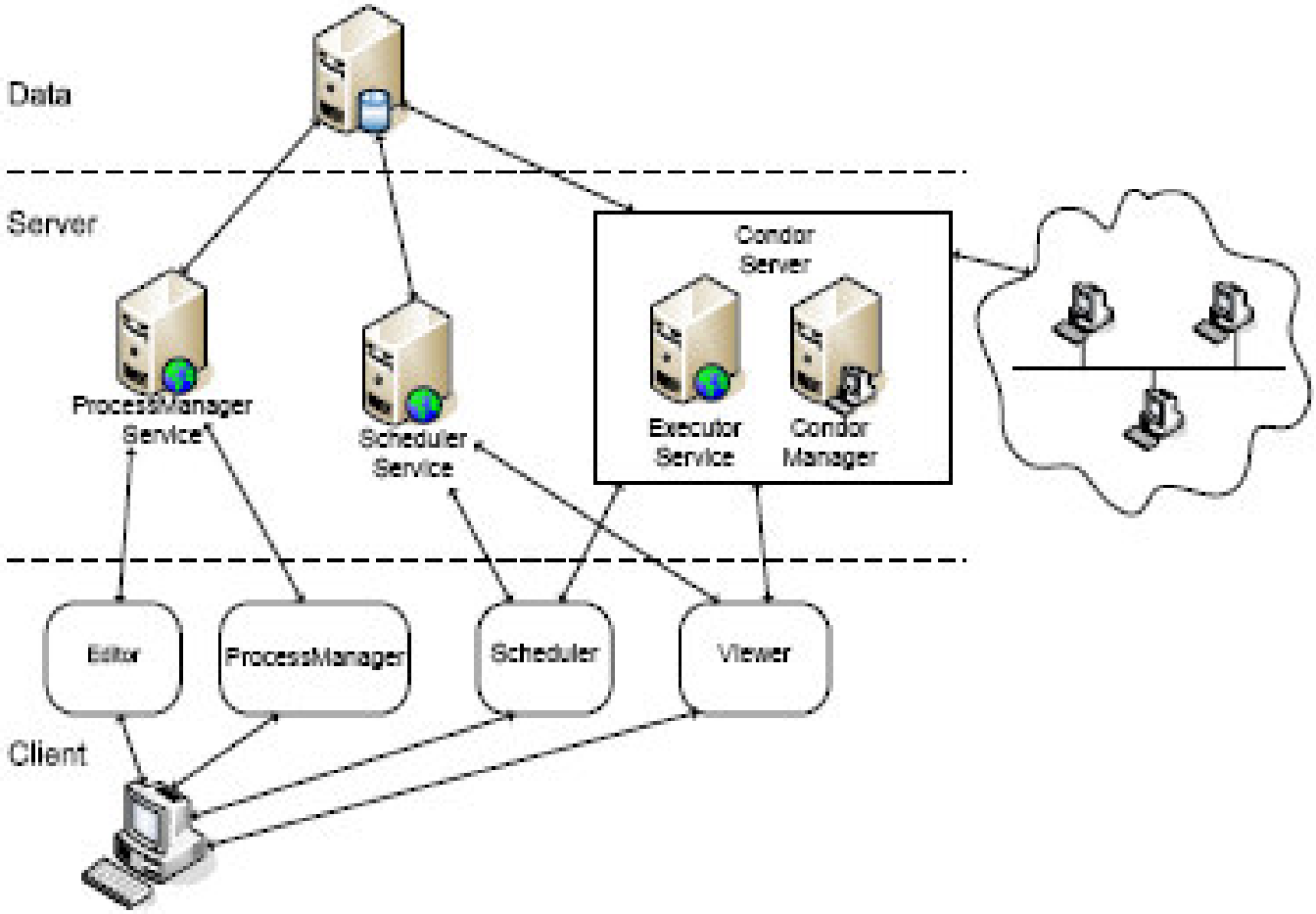
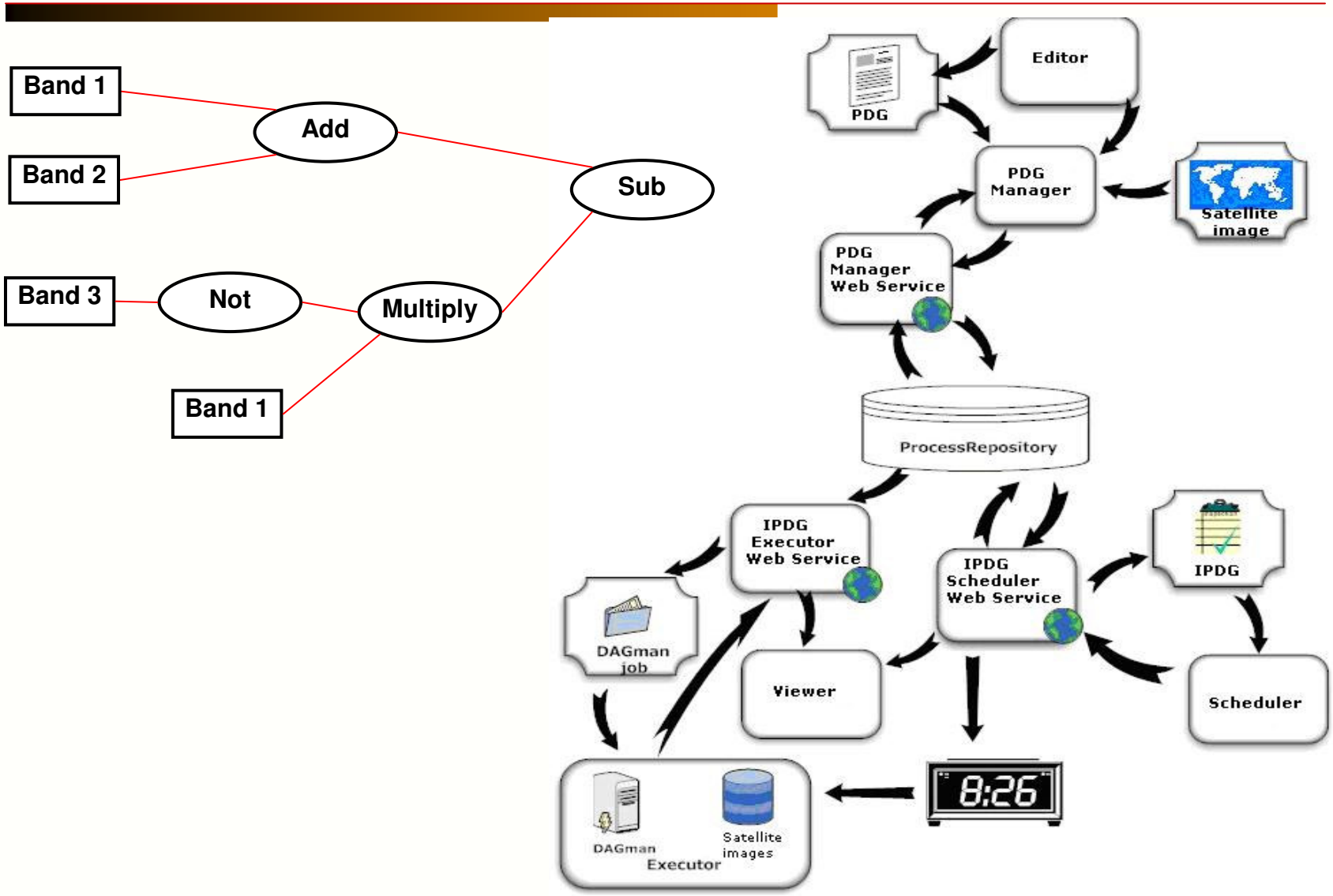
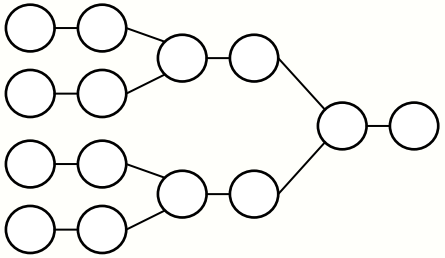


Figure 3. gProcess architecture.

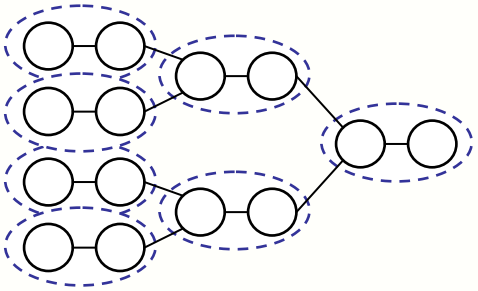
Process description graph based workflow



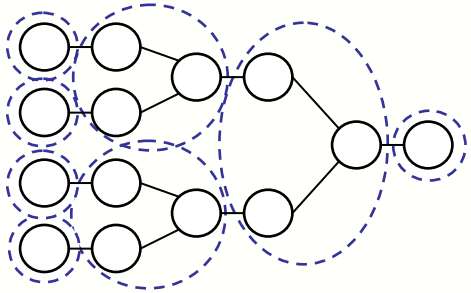
Graph based evaluation of satellite imagery processing over Grid



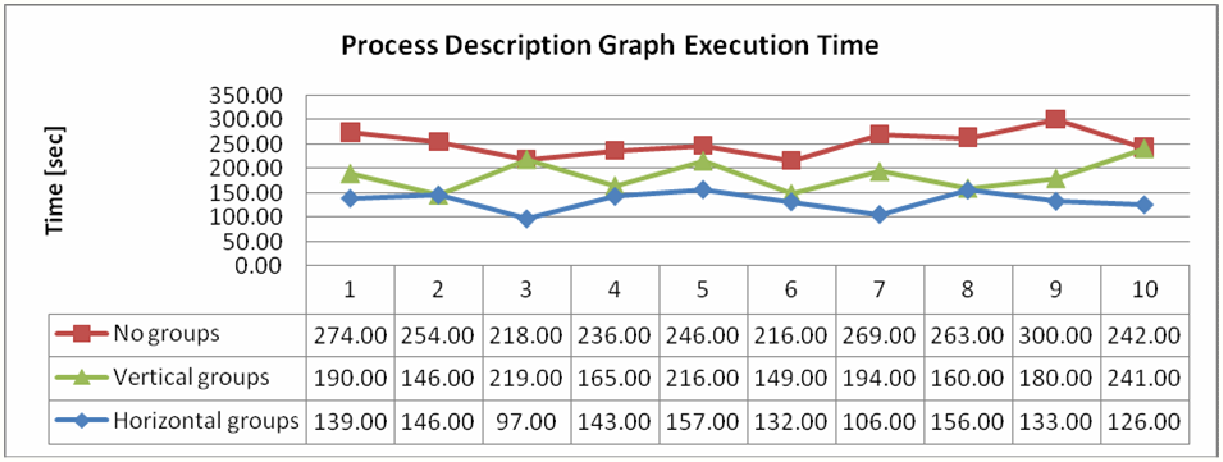
Test 1 – no operator groups.



Test 2 – horizontal operator groups.

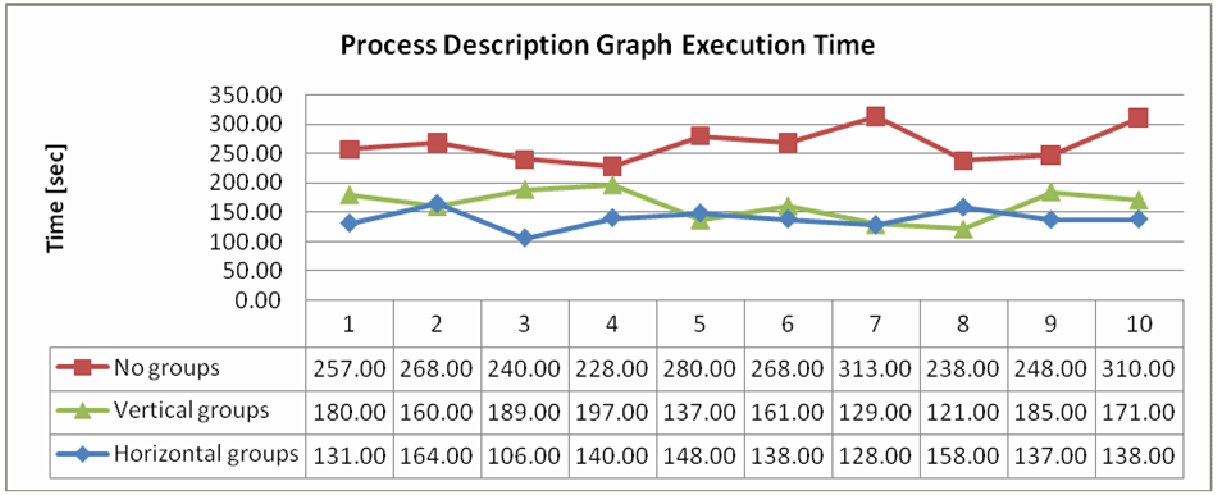


Test 3 – vertical operator groups.



	1	2	3	4	5	6	7	8	9	10
No groups	274.00	254.00	218.00	236.00	246.00	216.00	269.00	263.00	300.00	242.00
Vertical groups	190.00	146.00	219.00	165.00	216.00	149.00	194.00	160.00	180.00	241.00
Horizontal groups	139.00	146.00	97.00	143.00	157.00	132.00	106.00	156.00	133.00	126.00

Figure 6 Execution time (16 processing nodes).



	1	2	3	4	5	6	7	8	9	10
No groups	257.00	268.00	240.00	228.00	280.00	268.00	313.00	238.00	248.00	310.00
Vertical groups	180.00	160.00	189.00	197.00	137.00	161.00	129.00	121.00	185.00	171.00
Horizontal groups	131.00	164.00	106.00	140.00	148.00	138.00	128.00	158.00	137.00	138.00

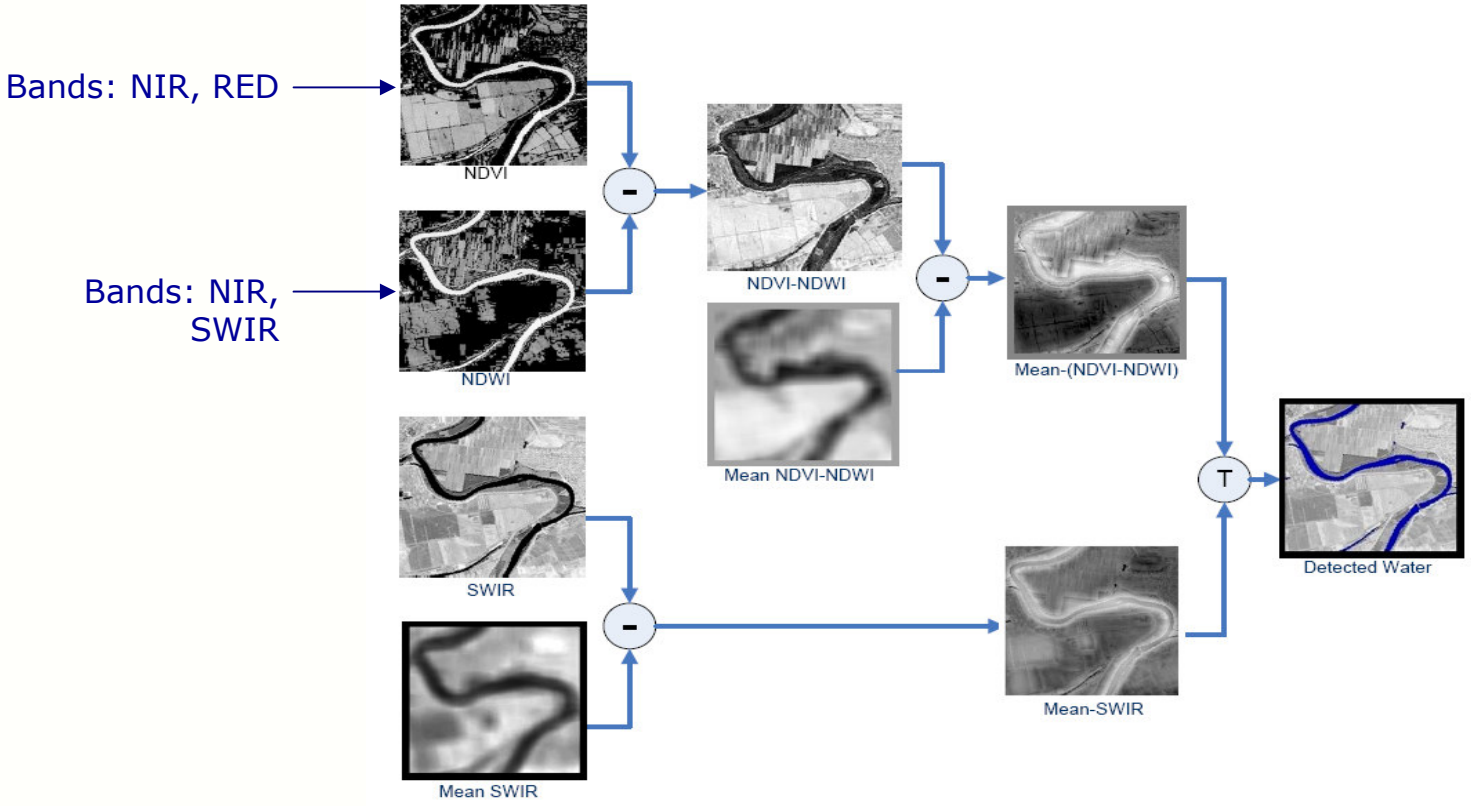
Figure 7 Execution time (59 processing nodes).

Gond's Water Detection Algorithm

- Gond's water detection algorithm

  Gond V., Bartholom E., Ouattara F., Nonguierma A. and Bado I. Surveillance et cartographie des plans d'eau et des zones humides et inondables en rgions arides avec l'instrument VEGETATION embarque sur Spot 4, International Journal of Remote Sensing, 2004, 25,5. pp. 987- 1004.

- SWIR (5), Red (3) and NIR (4) spectral bands



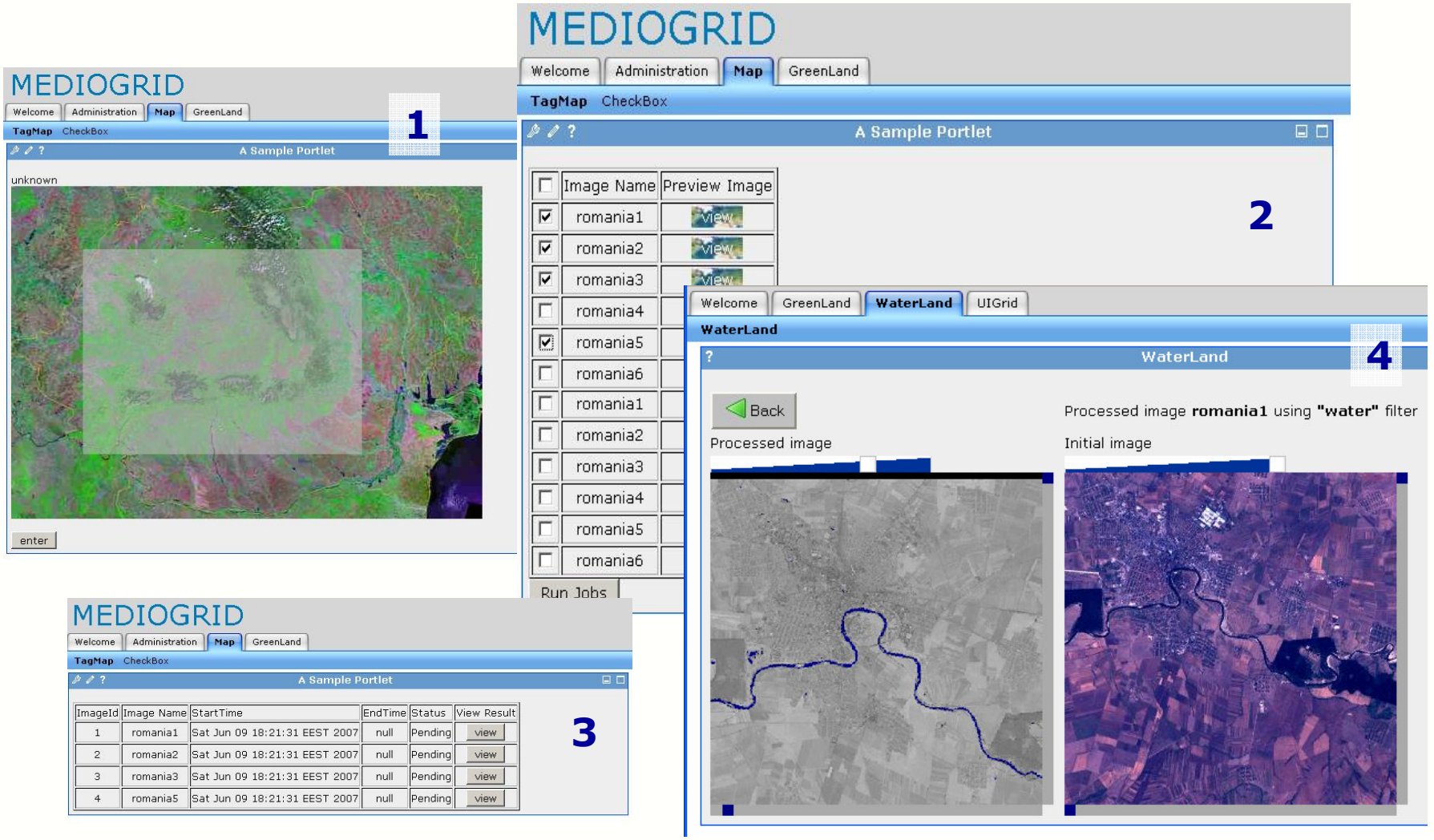
Water detection algorithm

Pseudo colored initial Landsat image.

Samples of detected water areas.

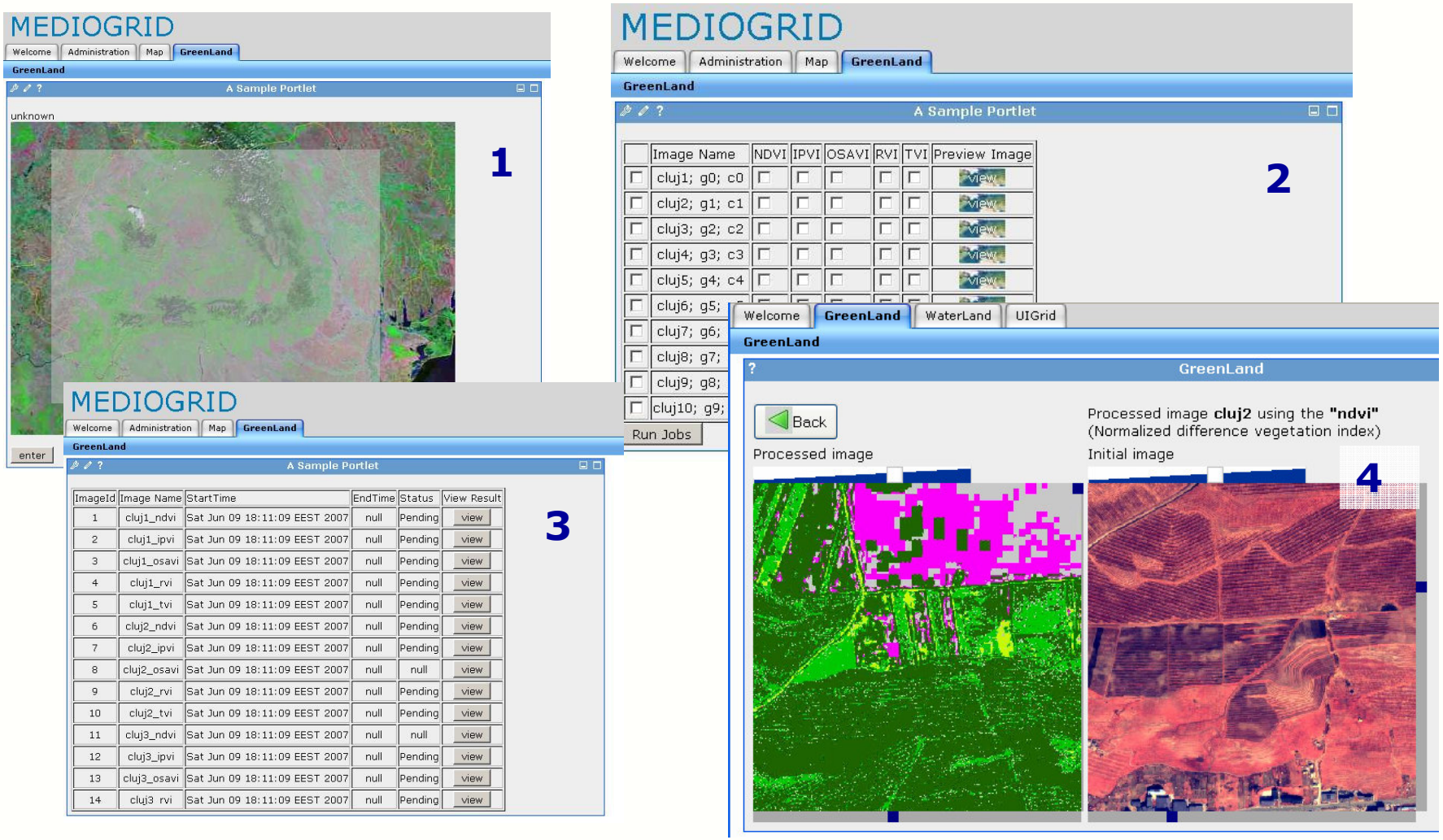
Waterland application

On-line available Web application: http://greenland.mediogrid.utcluj.ro

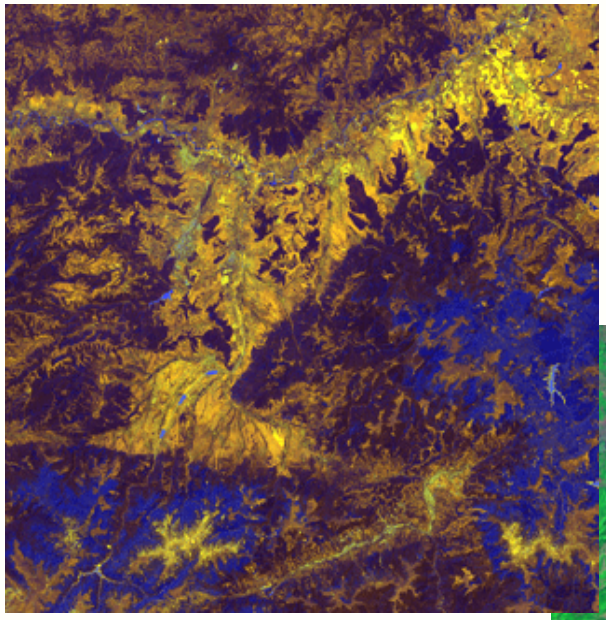


Greenland application

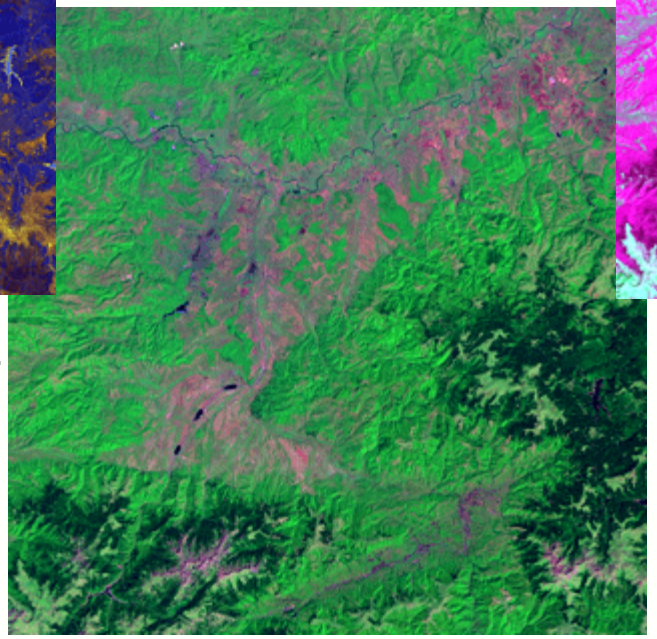
On-line available Web application: http://greenland.mediogrid.utcluj.ro

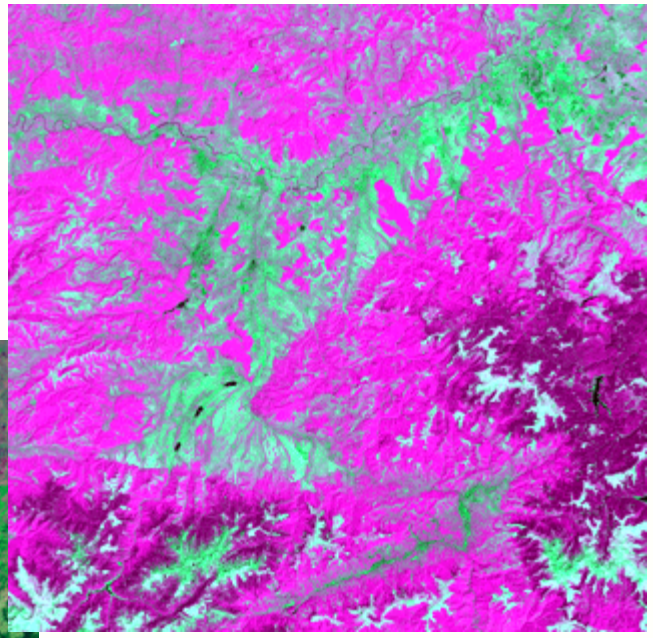


Minerals application



Hydrothermally-altered areas.



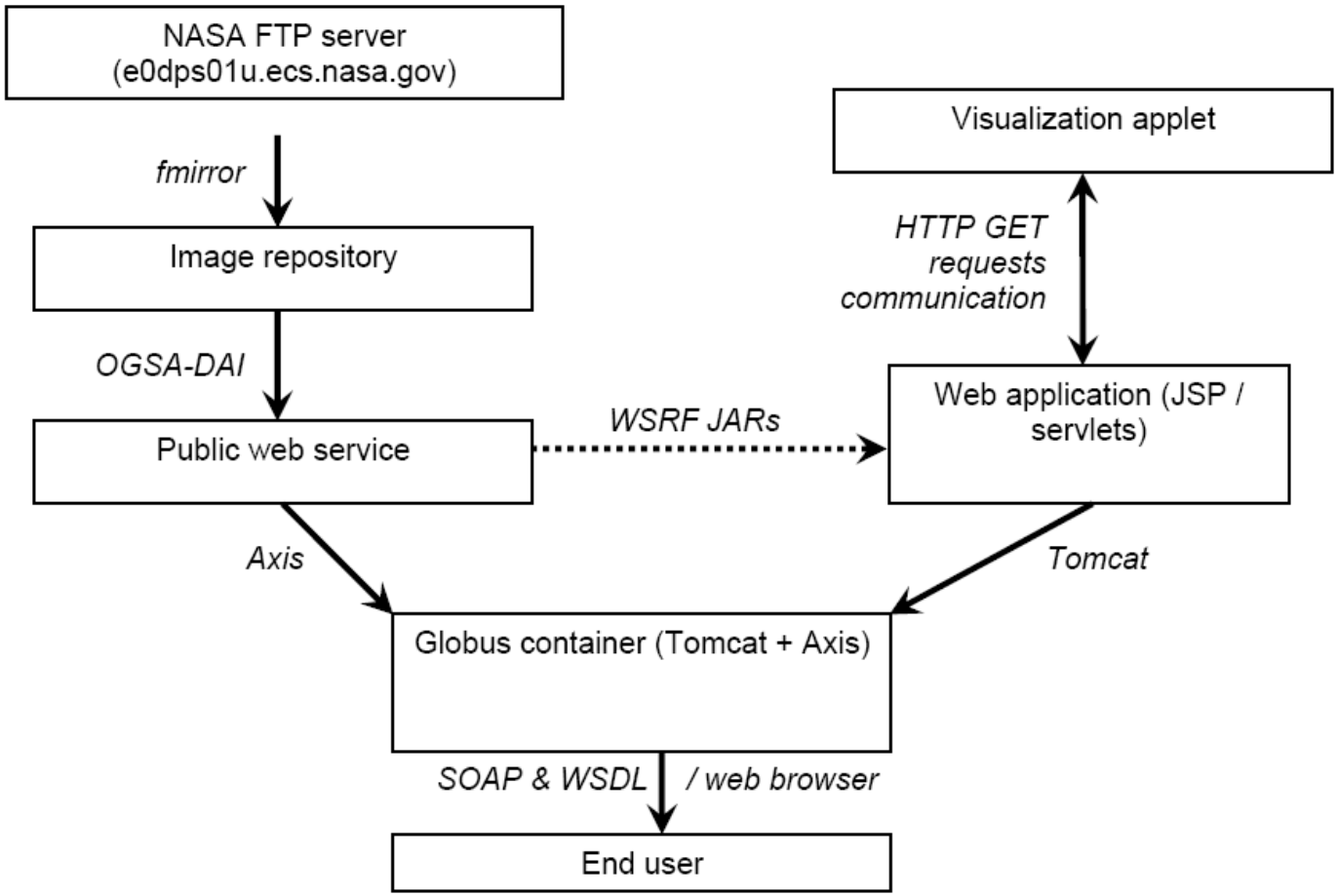


Iron-oxides and hydroxyl-bearings minerals.

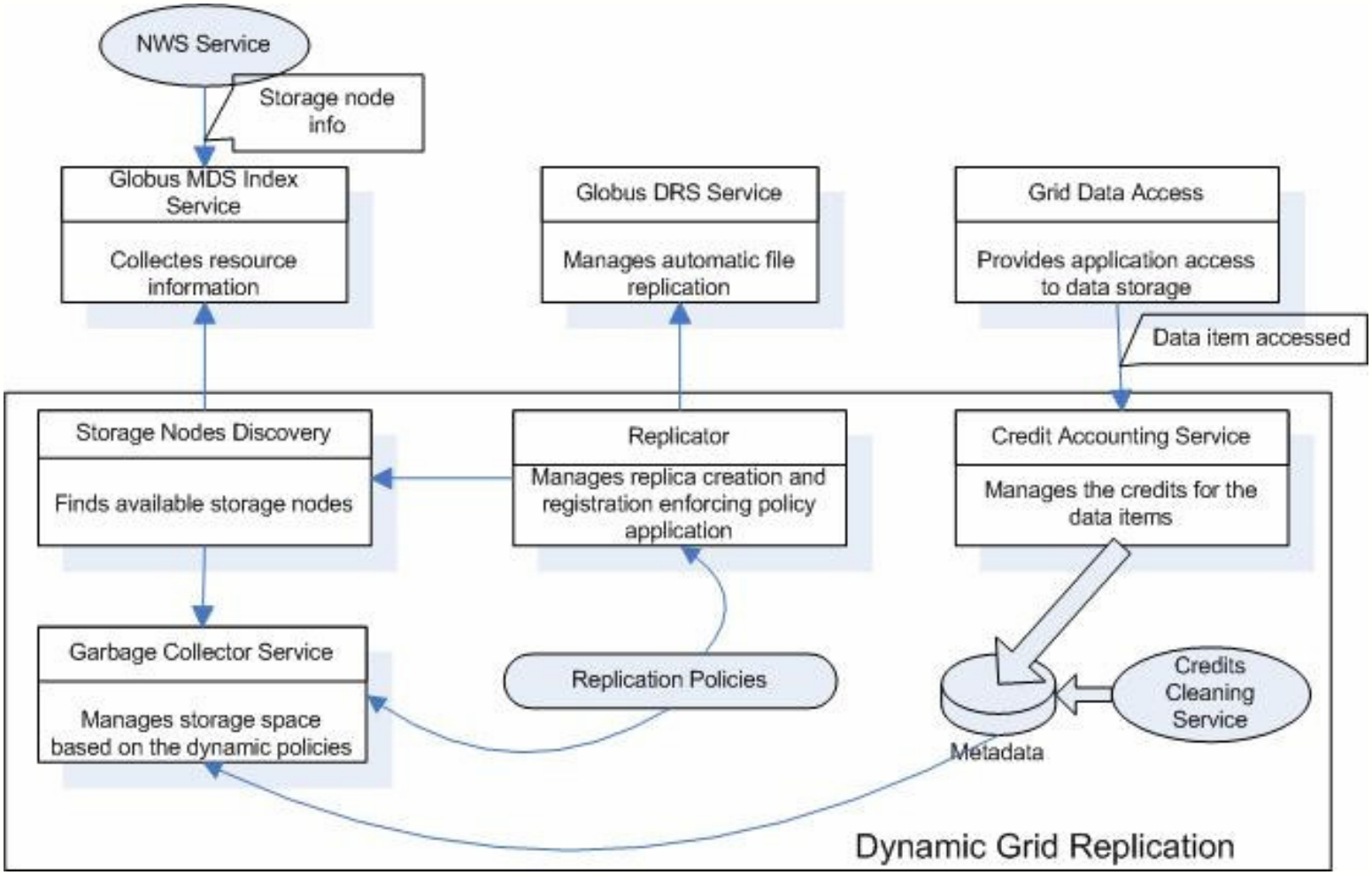
The Metaliferi Mountains area presented as a false color image (Band 7 by red, band 4 by green and band 2 by blue).

GENERIS component

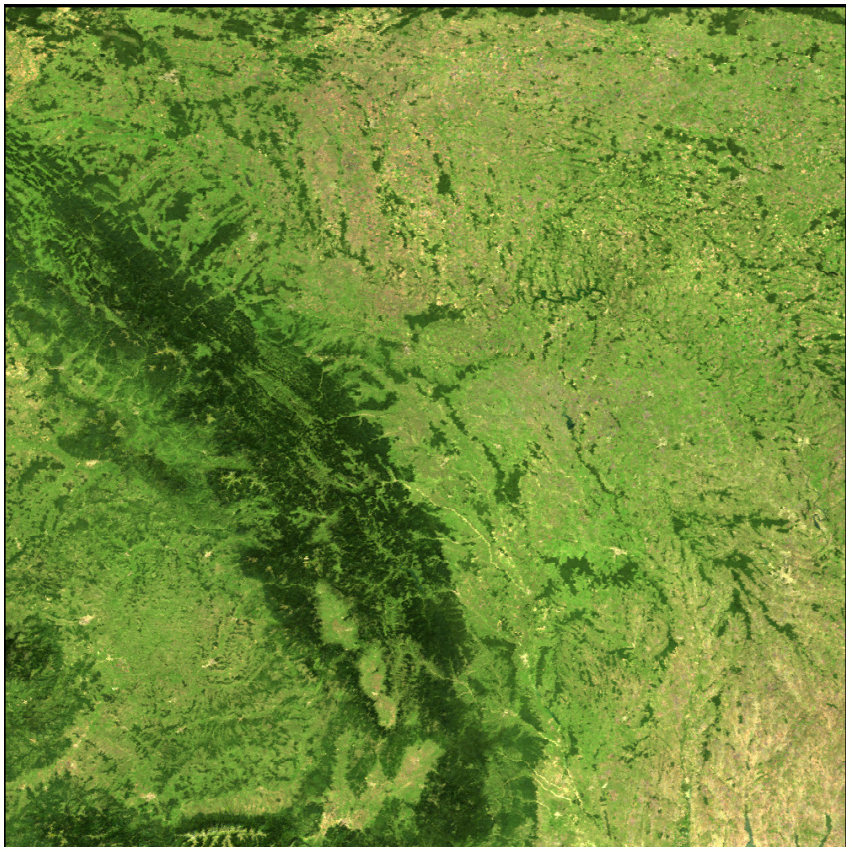
GENERIS (Grid based ENvironmEnt Representation and Information Service)



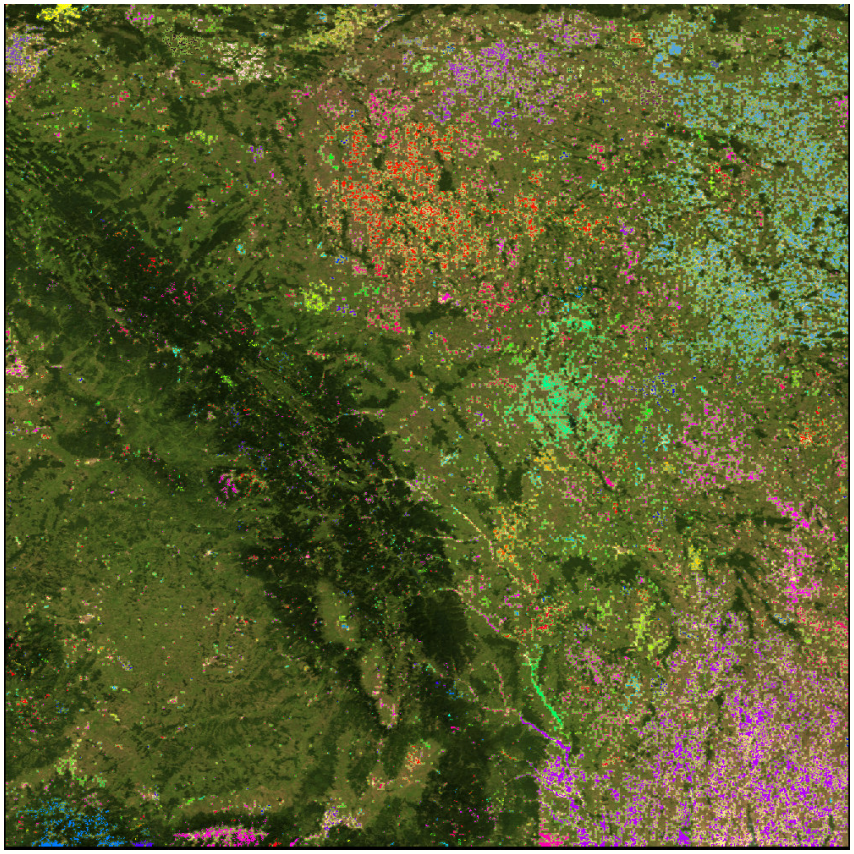
Data replication



Change detection

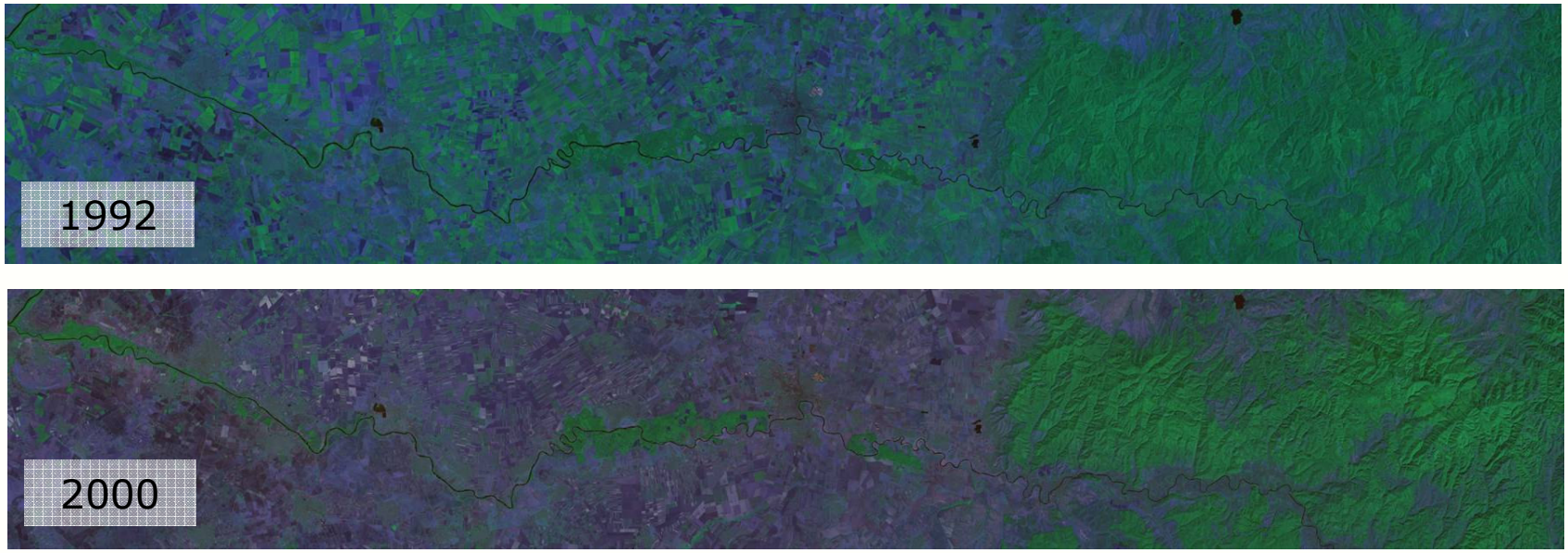


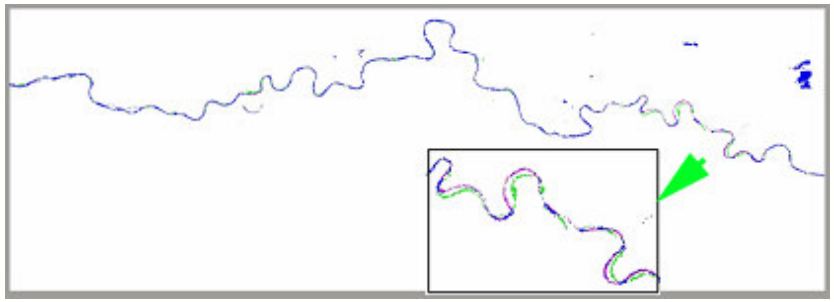
2004



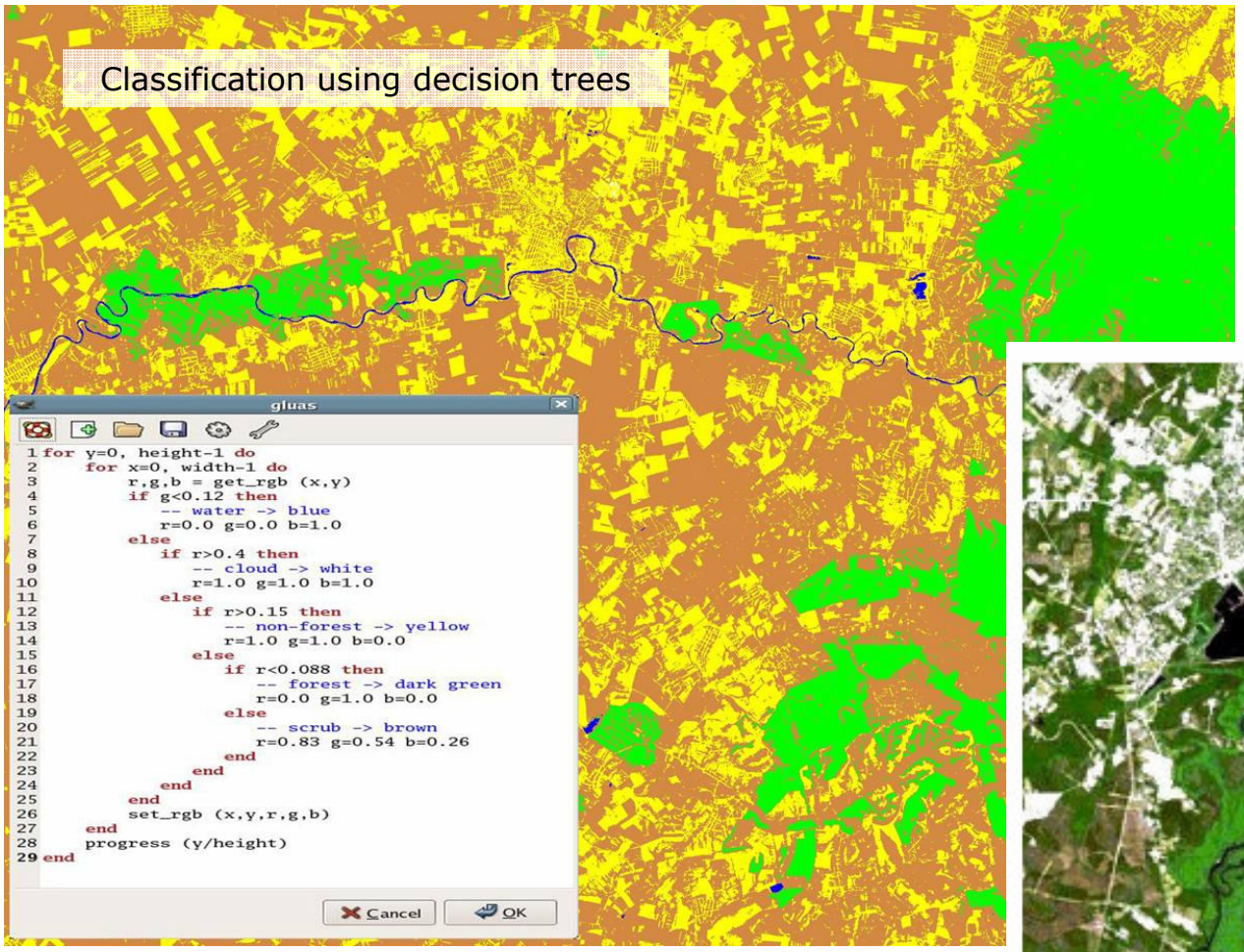
2005, with changes

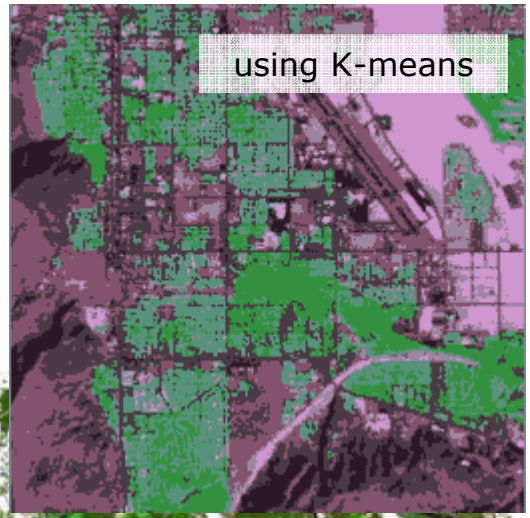
Change detection

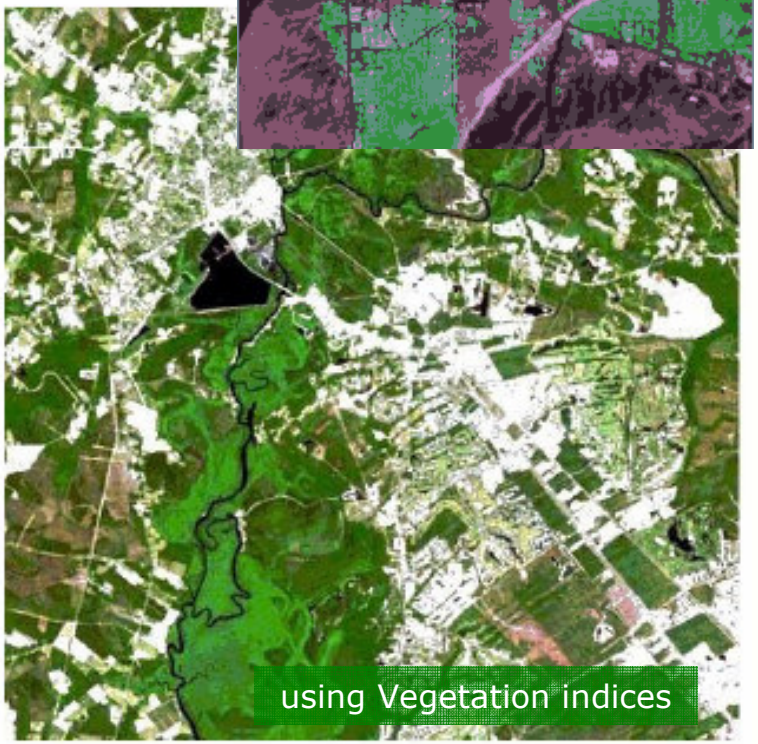




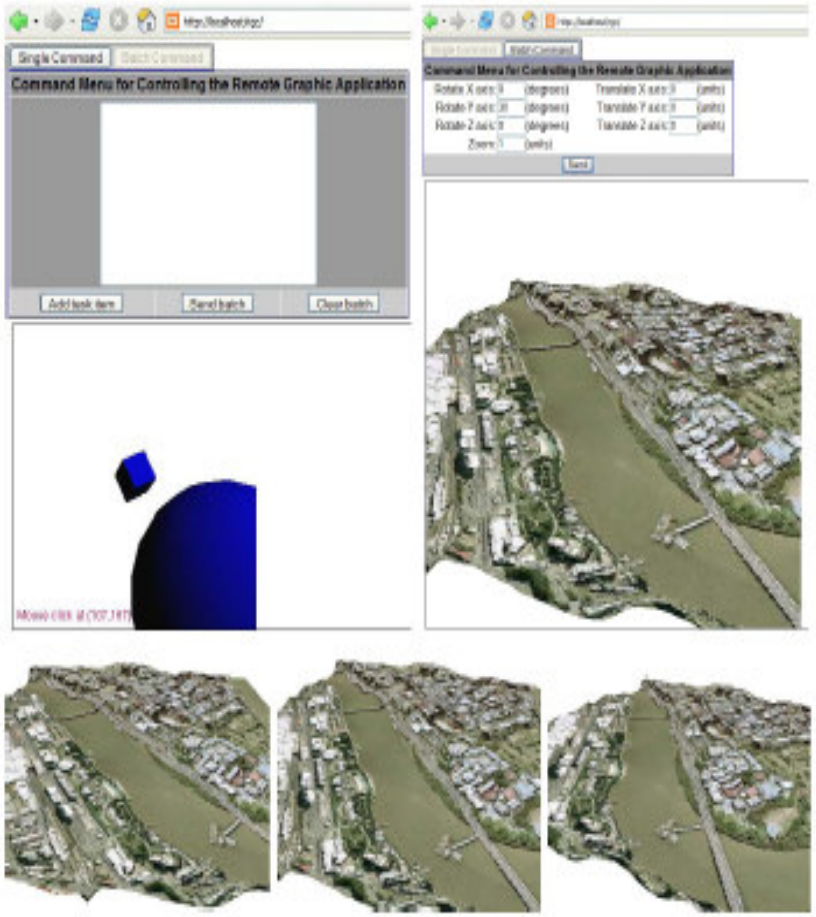
Satellite image classification and segmentation



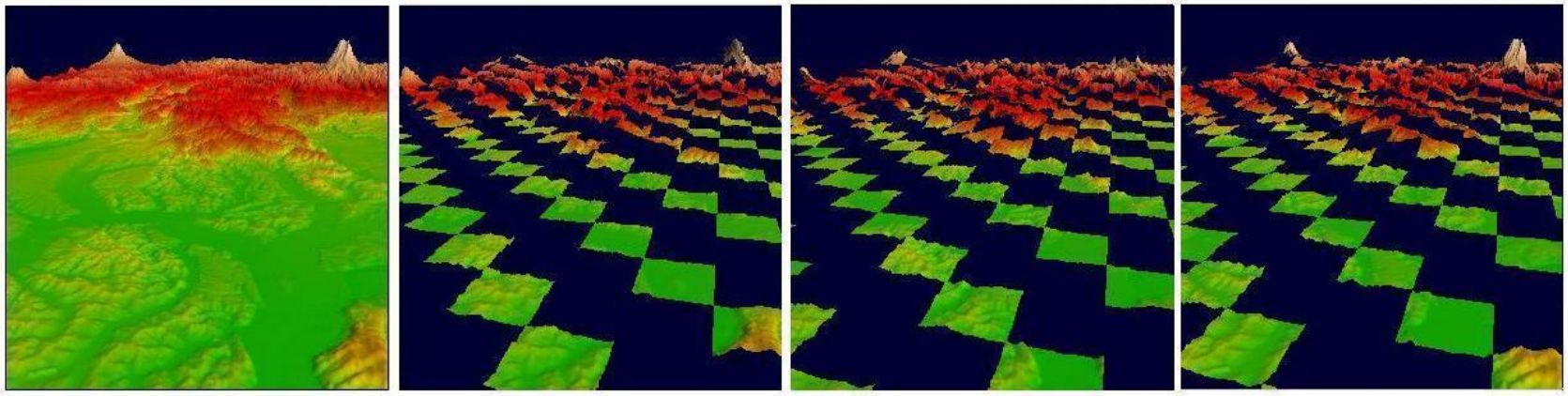




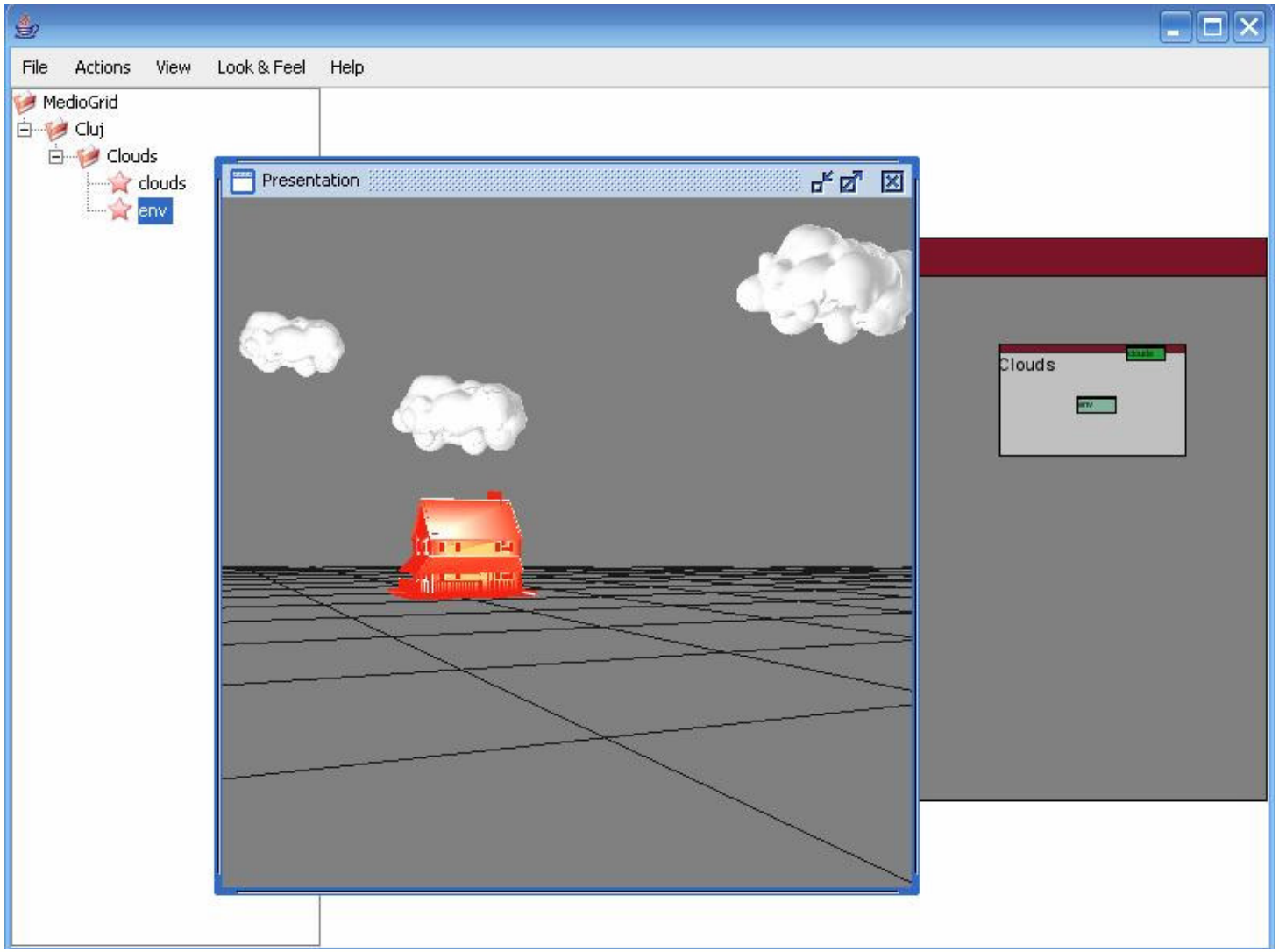
Remote control for graphic applications



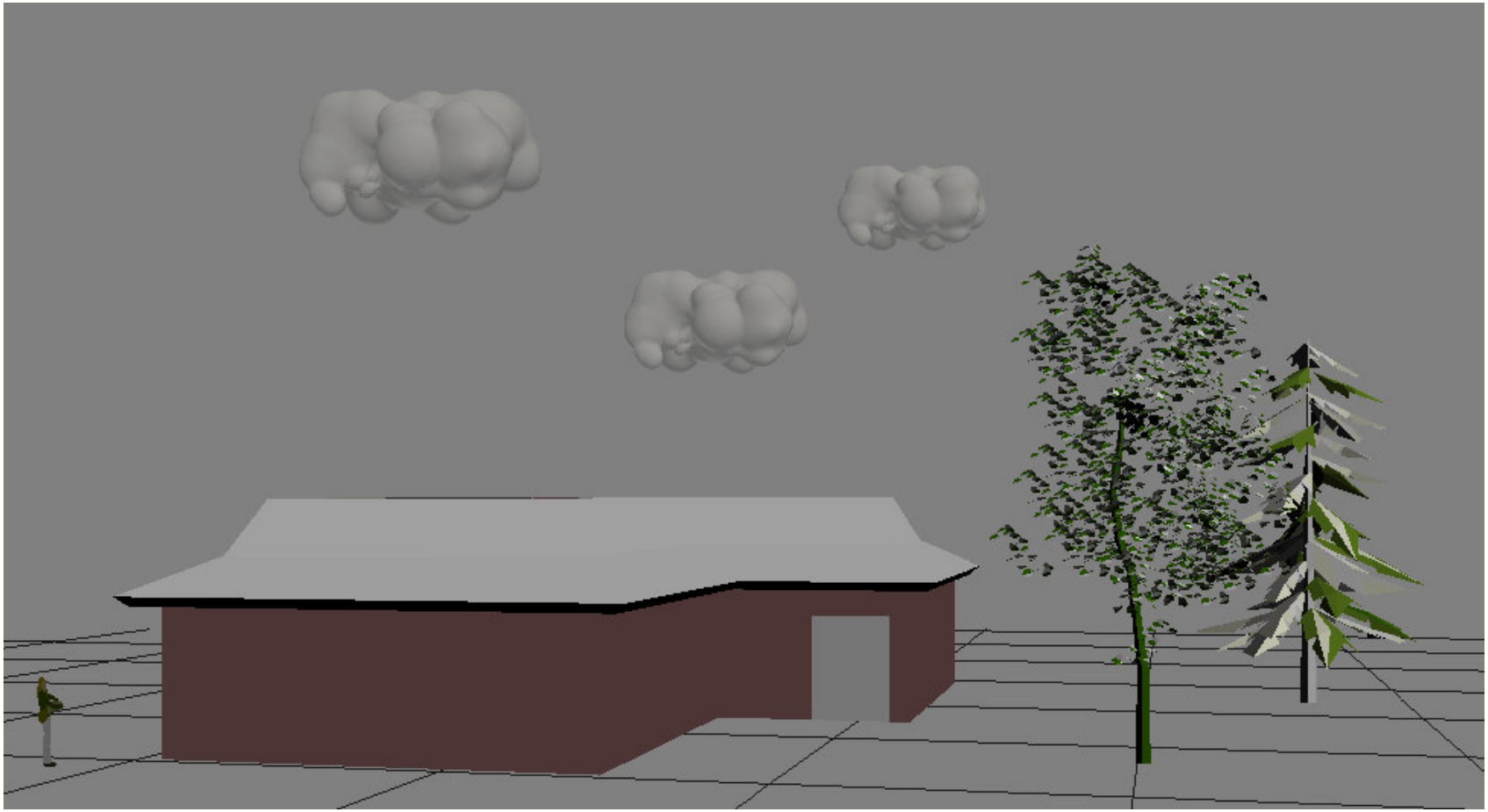
Parallel terrain rendering



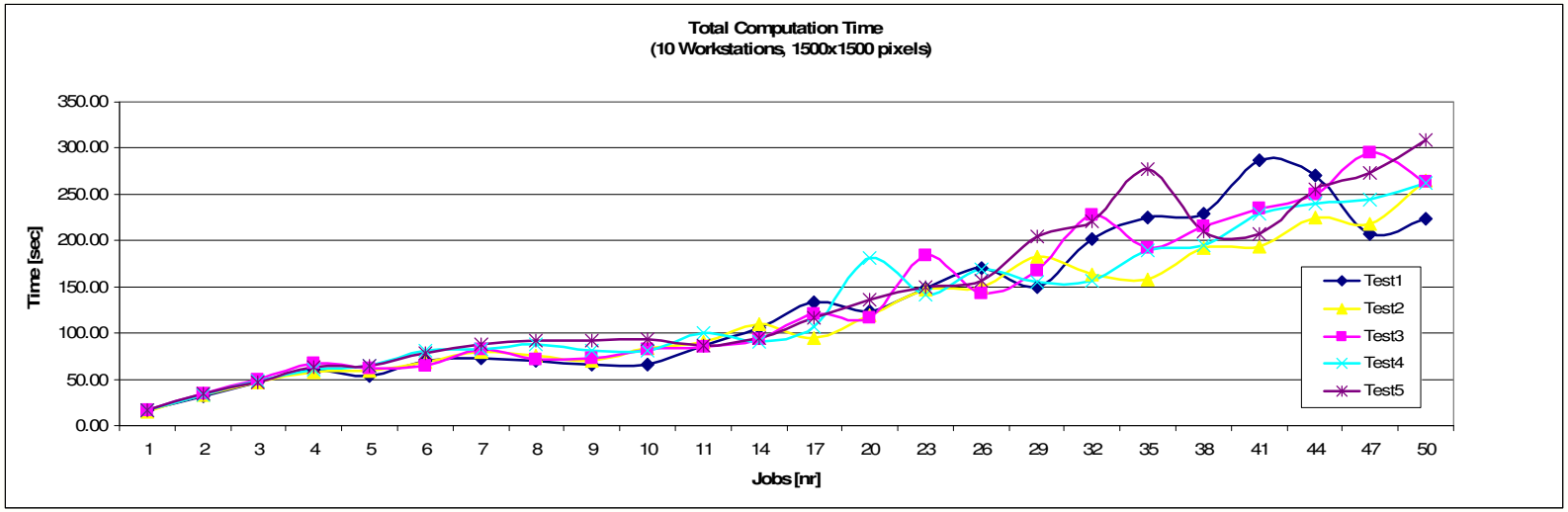
Virtual geographical space modeling

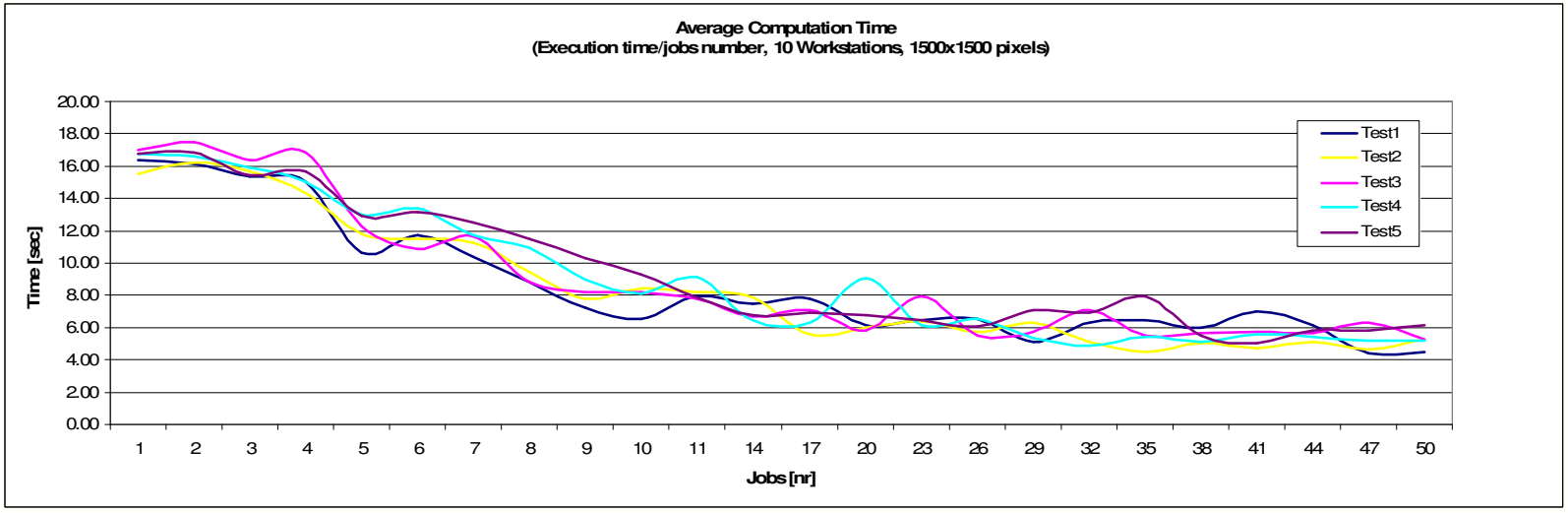


Virtual space visualization



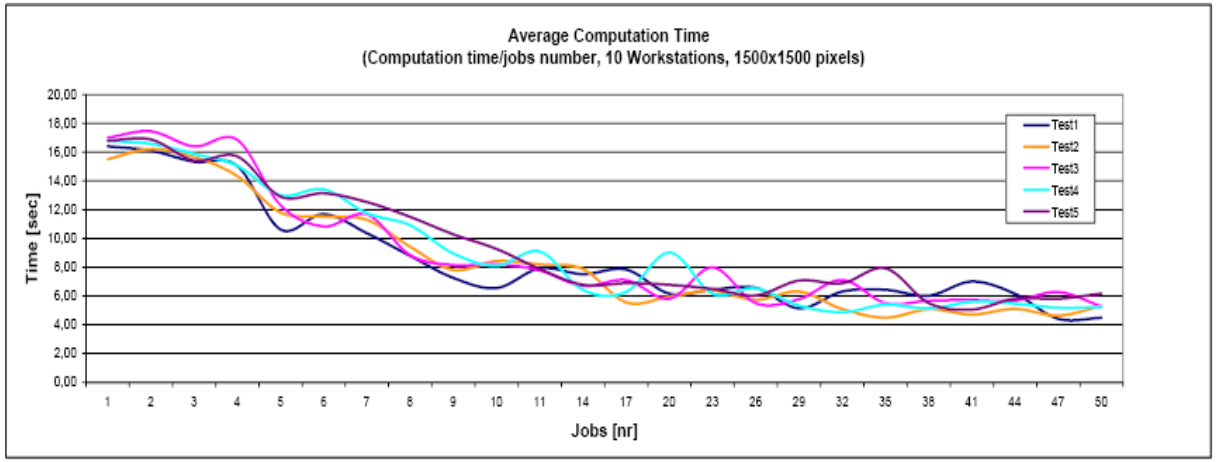
Performance evaluation

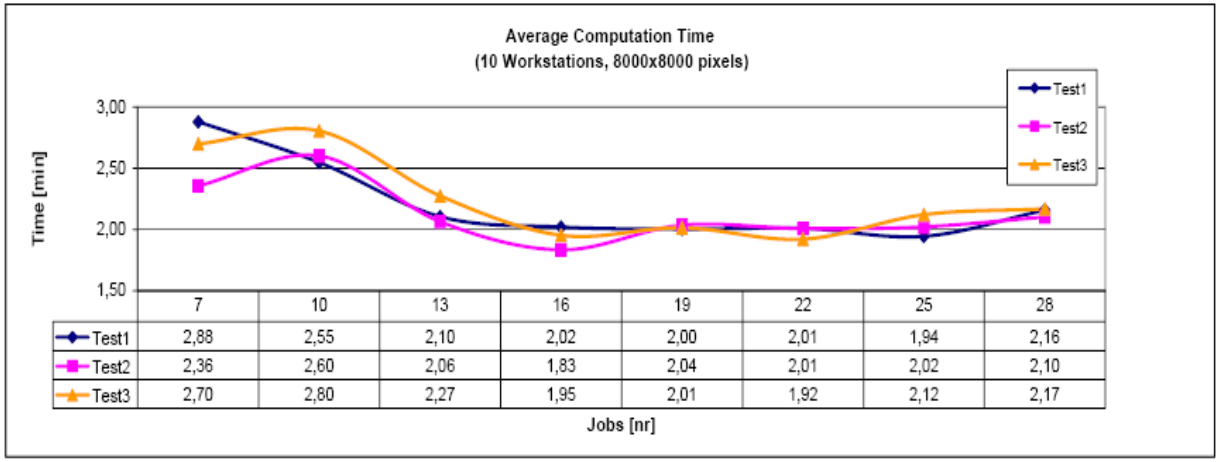




Performance evaluation

- Execution time / job on 1 workstation:
  - 17 sec for image of 1500x1500 pixels
  - 13 min for image of 8000x8000 pixels
- Execution time / job on 10 workstations:
  - 6 sec for image of 1500x1500 pixeli
  - 2.15 min for image of 8000x8000 pixeli





	7	10	13	16	19	22	25	28
Test1	2,88	2,55	2,10	2,02	2,00	2,01	1,94	2,16
Test2	2,36	2,60	2,06	1,83	2,04	2,01	2,02	2,10
Test3	2,70	2,80	2,27	1,95	2,01	1,92	2,12	2,17

Conclusions

- Future works:
  - Develop the Grid and Web services for geographical and environment applications
  - Grid Semantic services over MedioService Architecture
  - Geographical and Environmental Ontology and Knowledge Database
  - Geographical and environmental Grid pilot applications
  - Grid visualization
  - Active objects based distributed modeling and processing

Many thanks. Questions

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