

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**

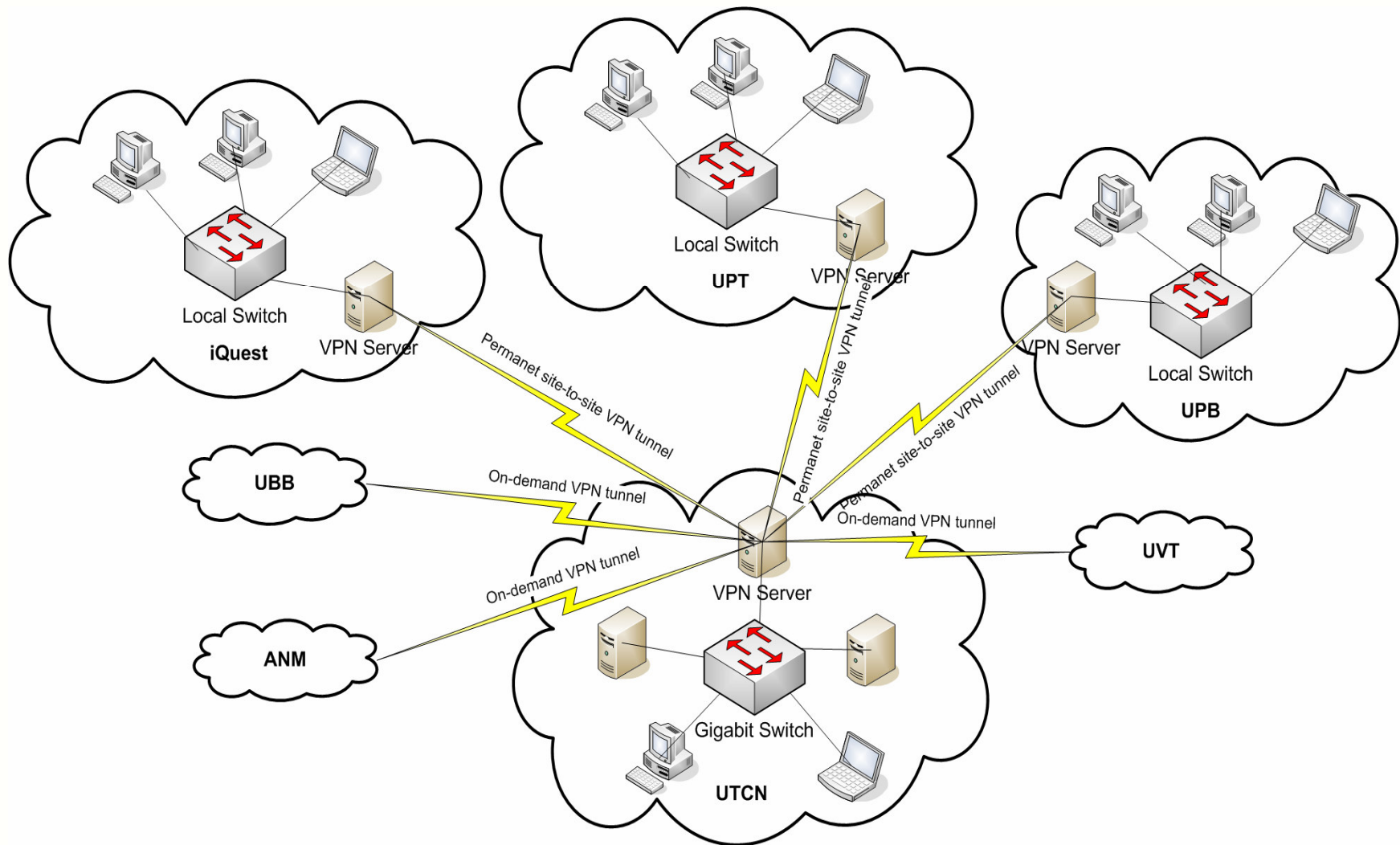


MedioGrid project' outcomes (2005-2008)

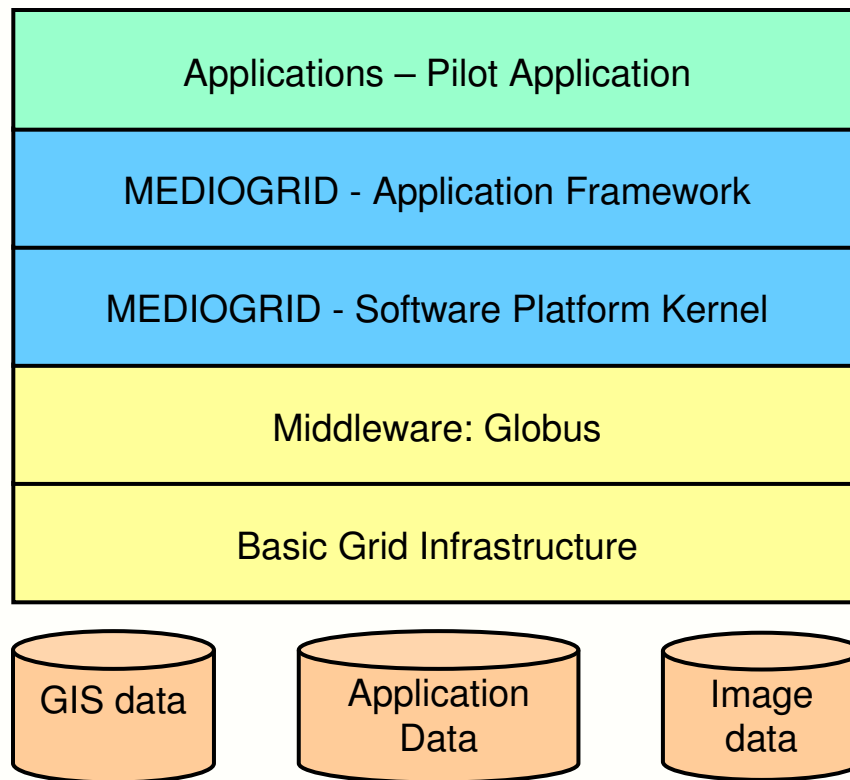
- Functional MedioGrid network (experimental Grid of 6 servers - Cluj, Timisoara, Bucharest and more than 100 workstations)
- Software applications: MedioGrid Software Platform Kernel, Image processing MODIS (NASA), Cloud detection, Vegetation classification (Greenland), Water detection (Waterland), 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

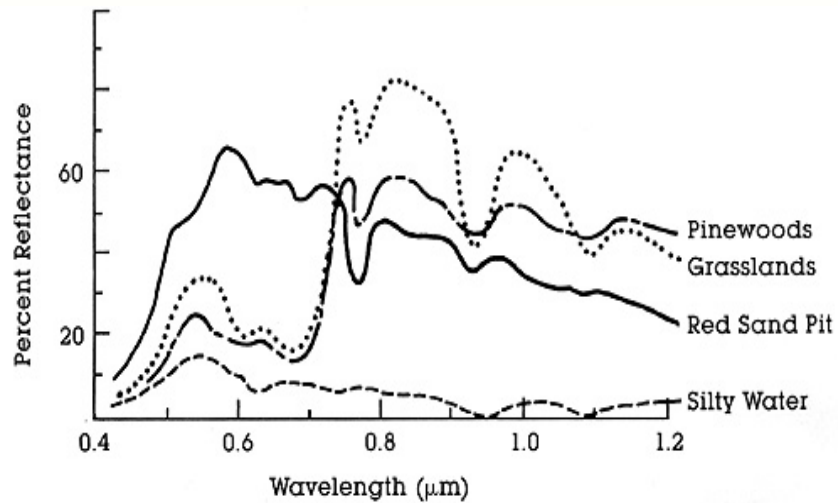


Functional MedioGrid layers



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

The screenshot displays the gProcess software interface with several overlapping windows:

- GRID Plan Processing:** Shows satellite image type selection (Landsat, MODIS, ASTER, IKONOS, ALI, TM) and a world map.
- Viewer:** A table showing process execution results.

Process State	Name	Image Bound	Time Start	Time End	Result
Process not started	Process Test	romania1	5/30/2007 8:35 ...		
Successfully finish...	Test	romania1	5/31/2007 5:01 ...	5/31/2007 5:07 ...	SchedProc70.tif
- GRID Plan Processing Editor:** A diagrammatic process description window showing a flowchart with input bands (B1, B2) and operations (Add, Multiply, Subtract, And).
- ProcessManager:** A configuration window for a process.

Id:	17
Name:	Process Test
Author:	Anca Radu
Latitude1:	44 ° 10 ' 2 " 1
Latitude2:	46 ° 6 ' 1 " <input checked="" type="checkbox"/> Scheduled
Longitude1:	
Longitude2:	
Time Start:	10/01/2007 09:01:08
Time End:	10/01/2007 09:01:08
- Scheduler:** A window showing process groups and a table of scheduled tasks.

Metadata Id	Process Groups	Process State	Time Start	Time End	Author	Name
34	{Invert-3 Add-1 Multiply-2 Subtract-4 } {Add-1 Multiply-2 Subtract-4 }Invert-3 } {Add-1 Multiply-2 }Invert-3 }Subtract-4 }					
37	{Add-1 Multiply-2 }Invert-3 }Subtract-4 }					
38	{Add-1 Multiply-2 }Invert-3 }Subtract-4 }	Successfully finish...	5/31/2007 5:01 ...	5/31/2007 5:07 ...	Calc	Test
39	{Add-1 }Invert-3 Multiply-2 Subtract-4 }				Calc	Test
40	{Add-1 }Multiply-2 Subtract-4 }Invert-3 }				Calc	Test
41	{Add-1 }Multiply-2 }Invert-3 }Subtract-4 }				Calc	Test



gProcess architecture

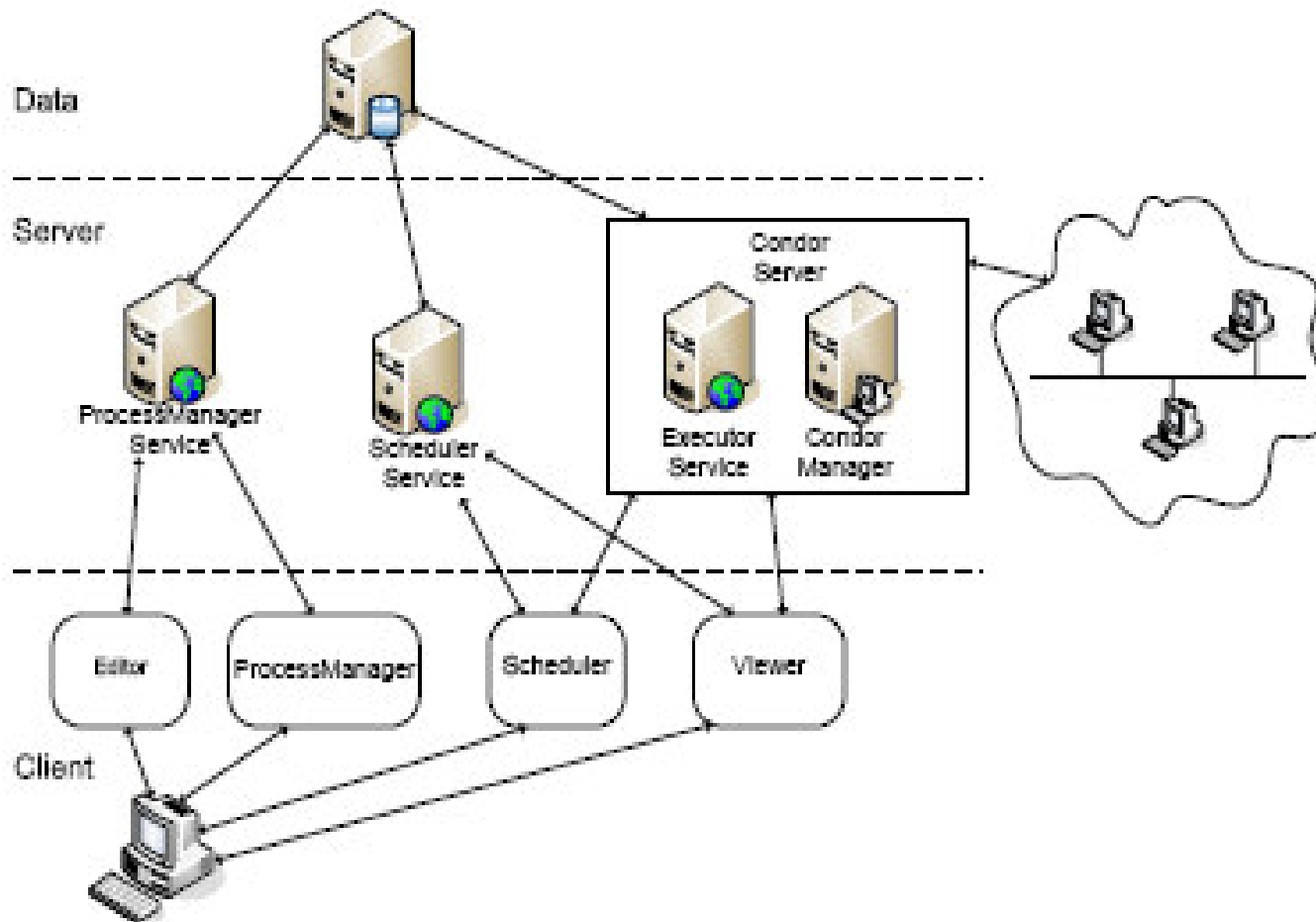
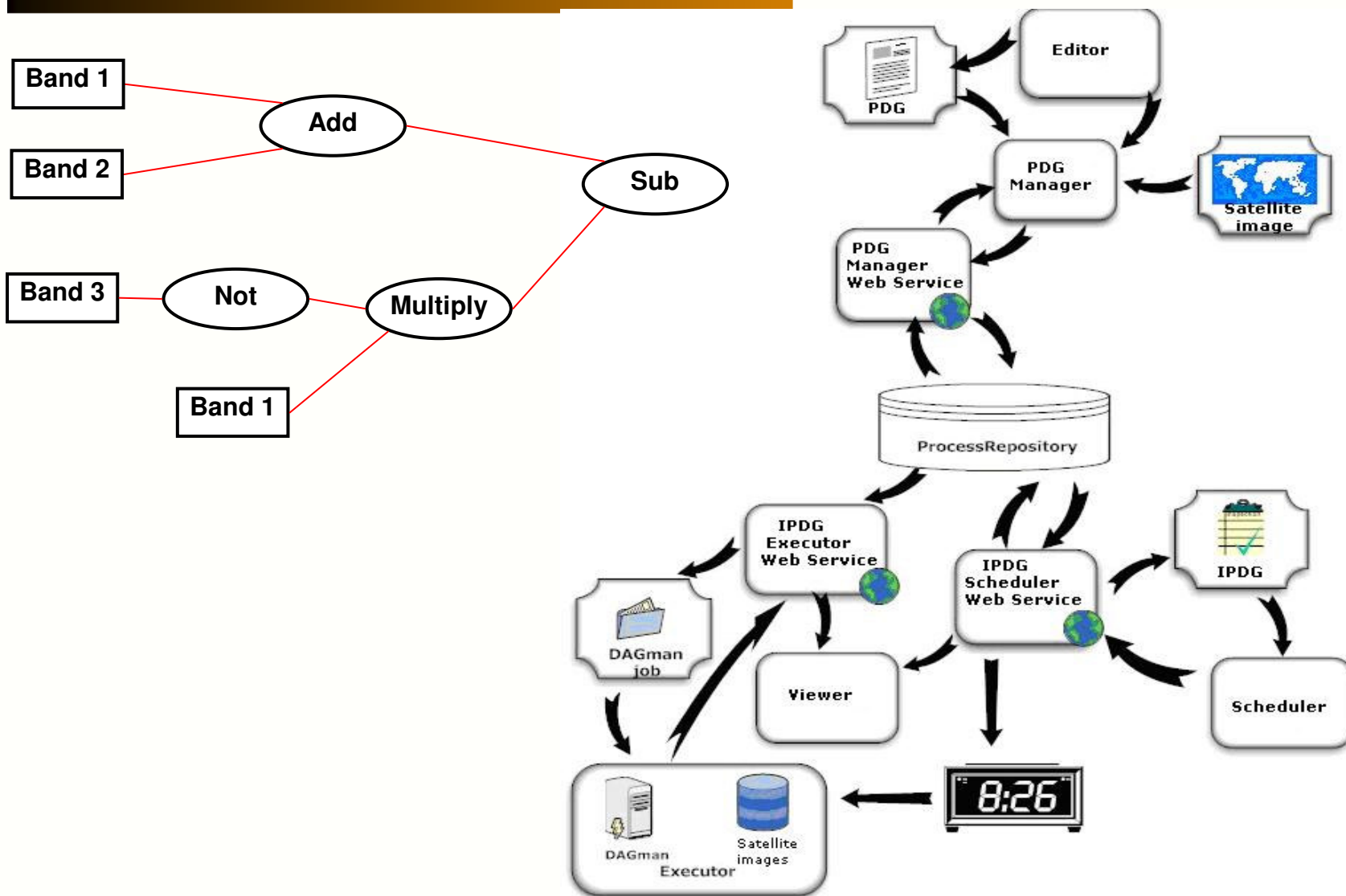
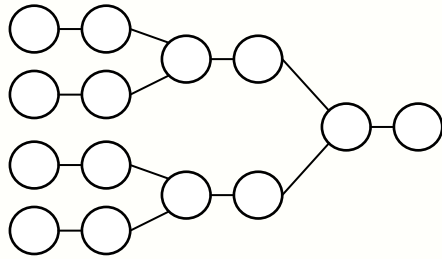


Figure 3. gProcess architecture.

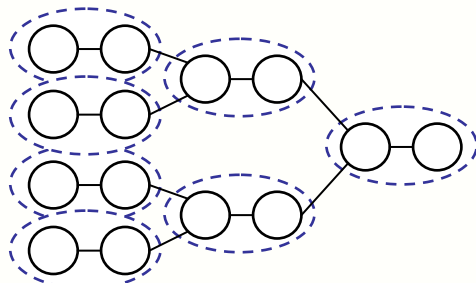
Process description graph based workflow



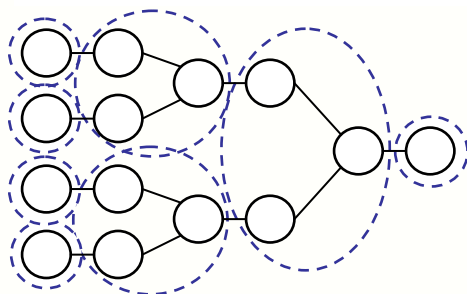
Graph based evaluation of satellite imagery processing over Grid



Test 1 – no operator groups.



Test 2 – horizontal operator groups.



Test 3 – vertical operator groups.

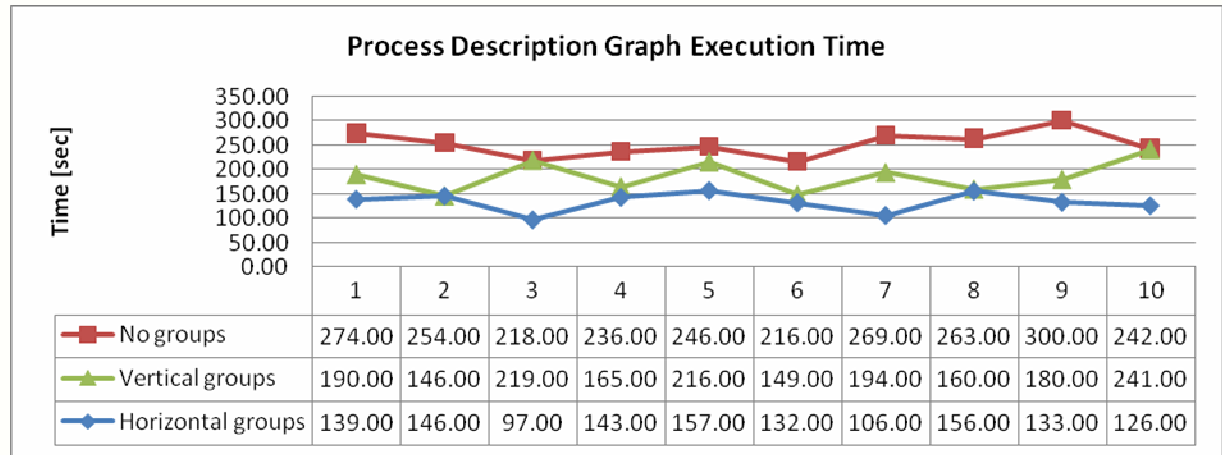


Figure 6 Execution time (16 processing nodes).

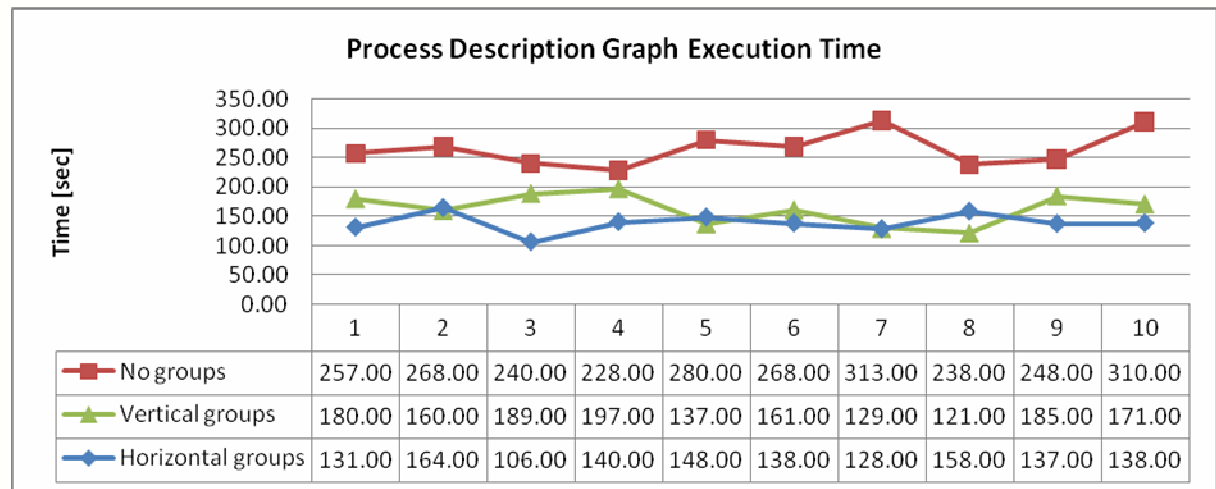


Figure 7 Execution time (59 processing nodes).

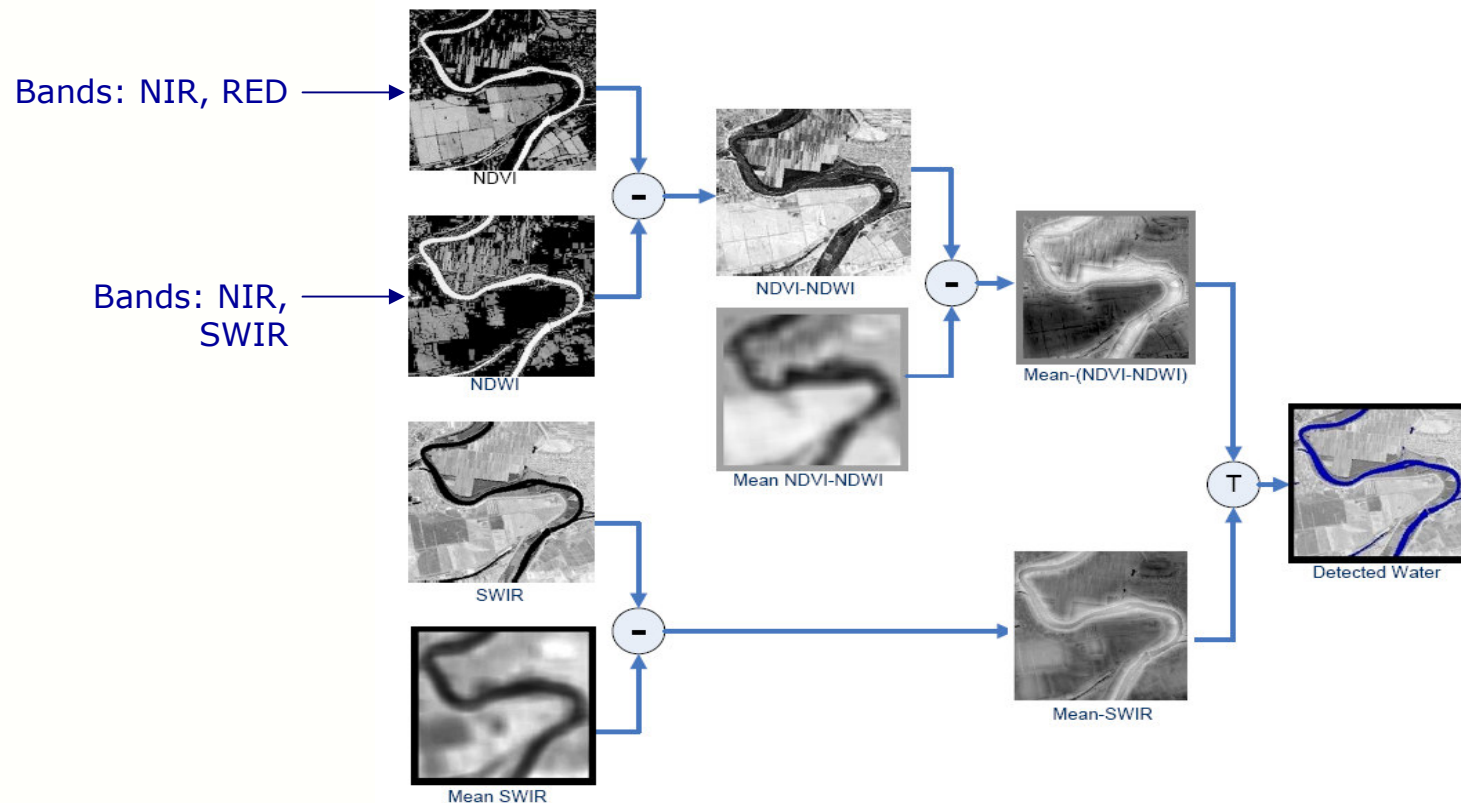


Gond's Water Detection Algorithm

- 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>

1

2

3

4

ImageId	Image Name	StartTime	EndTime	Status	View Result
1	romania1	Sat Jun 09 18:21:31 EEST 2007	null	Pending	view
2	romania2	Sat Jun 09 18:21:31 EEST 2007	null	Pending	view
3	romania3	Sat Jun 09 18:21:31 EEST 2007	null	Pending	view
4	romania5	Sat Jun 09 18:21:31 EEST 2007	null	Pending	view



Greenland application

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

The screenshots illustrate the following steps in the application:

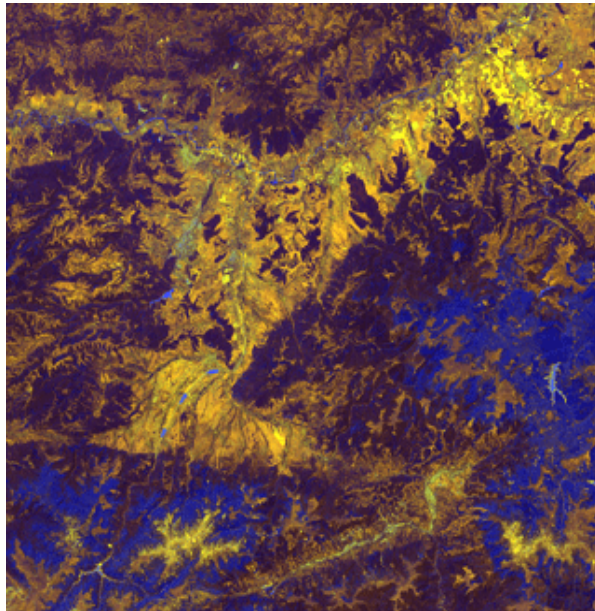
- 1**: A satellite image of a landscape with a semi-transparent processing box overlaid.
- 2**: A table listing image names and their corresponding indices for various indices (NDVI, IPVI, OSAVI, RVI, TVI). Each row includes a checkbox and a 'View' button.
- 3**: A table showing the status of processing jobs for various image names and indices.
- 4**: A comparison between the 'Processed image' (using NDVI) and the 'Initial image'.

Image Name	NDVI	IPVI	OSAVI	RVI	TVI	Preview Image
<input type="checkbox"/> cluj1; g0; c0	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> cluj2; g1; c1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> cluj3; g2; c2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> cluj4; g3; c3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> cluj5; g4; c4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<input type="checkbox"/> cluj6; g5;						
<input type="checkbox"/> cluj7; g6;						
<input type="checkbox"/> cluj8; g7;						
<input type="checkbox"/> cluj9; g8;						
<input type="checkbox"/> cluj10; g9;						

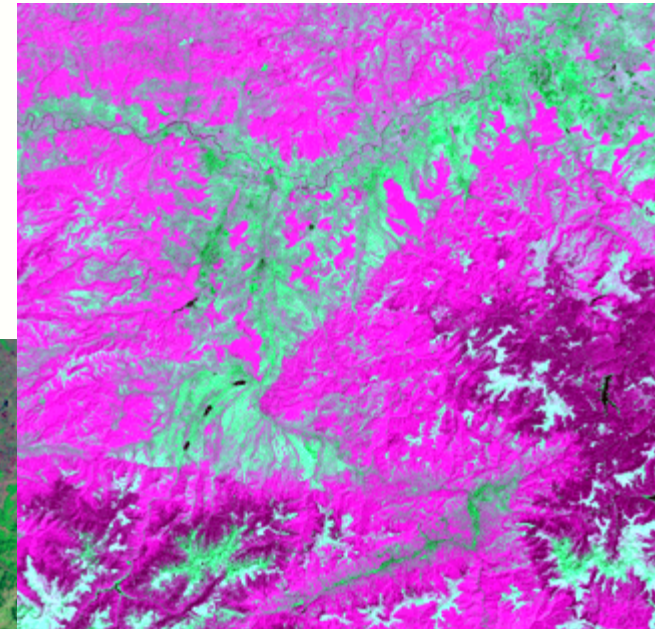
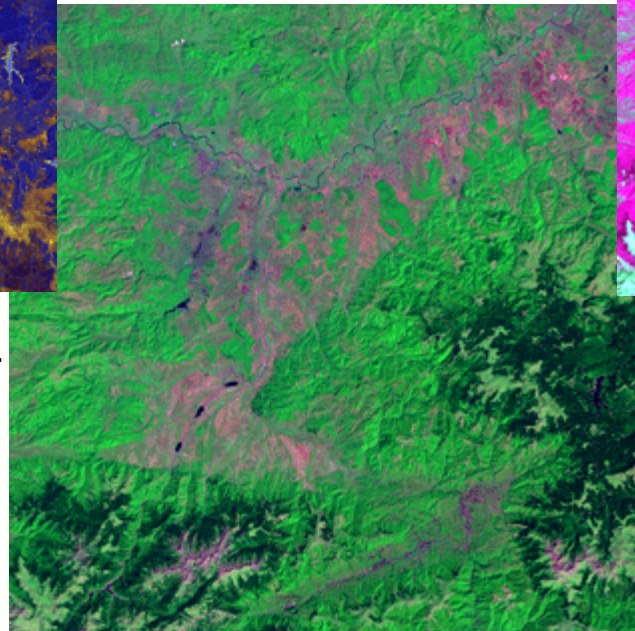
ImageId	Image Name	StartTime	EndTime	Status	View Result
1	cluj1_ndvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
2	cluj1_ipvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
3	cluj1_osavi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
4	cluj1_rvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
5	cluj1_tv	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
6	cluj2_ndvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
7	cluj2_ipvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
8	cluj2_osavi	Sat Jun 09 18:11:09 EEST 2007	null	null	view
9	cluj2_rvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
10	cluj2_tv	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
11	cluj3_ndvi	Sat Jun 09 18:11:09 EEST 2007	null	null	view
12	cluj3_ipvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
13	cluj3_osavi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view
14	cluj3_rvi	Sat Jun 09 18:11:09 EEST 2007	null	Pending	view



Minerals application



Hydrothermally-altered areas.



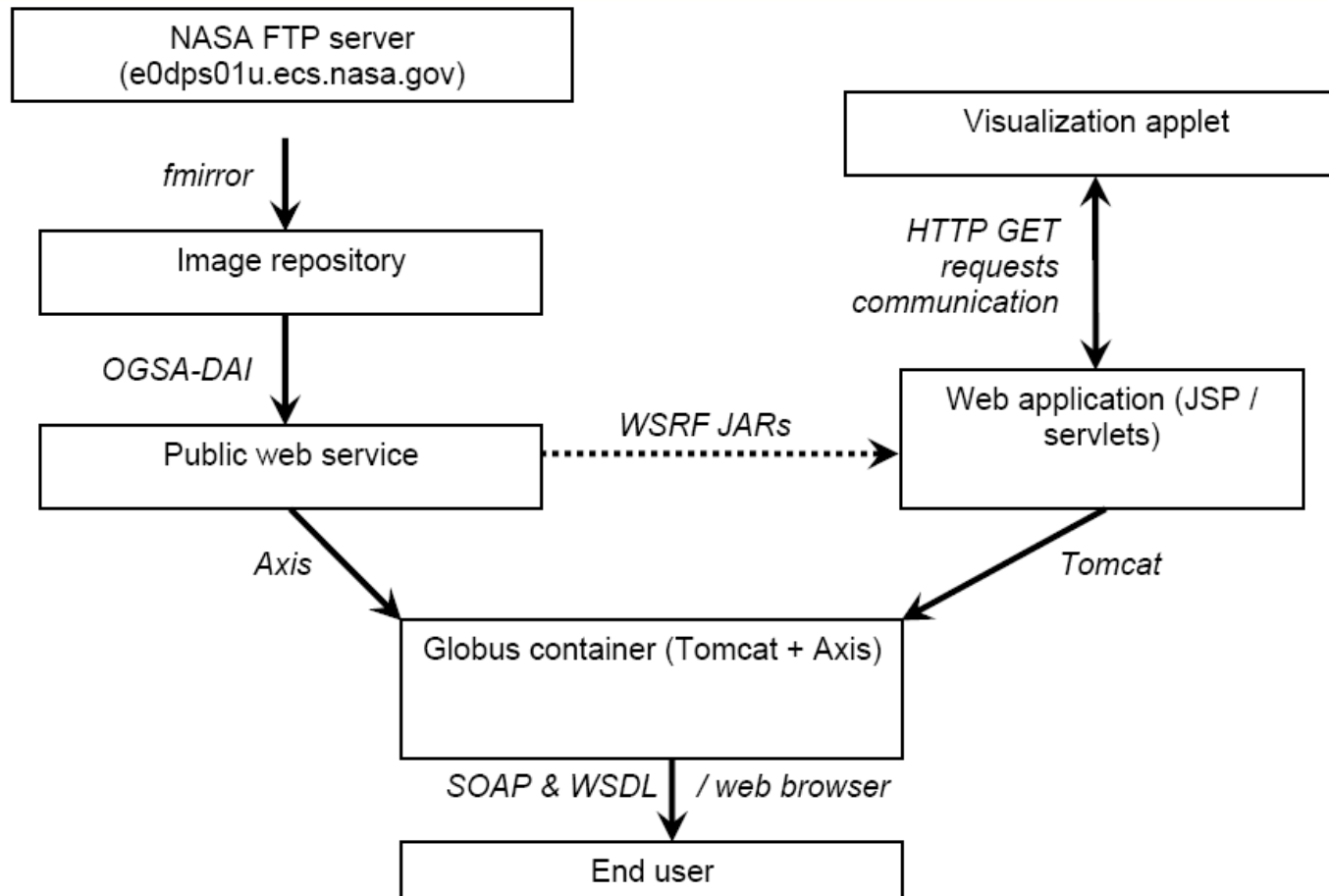
Iron-oxides and hydroxyl-bearing minerals.

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

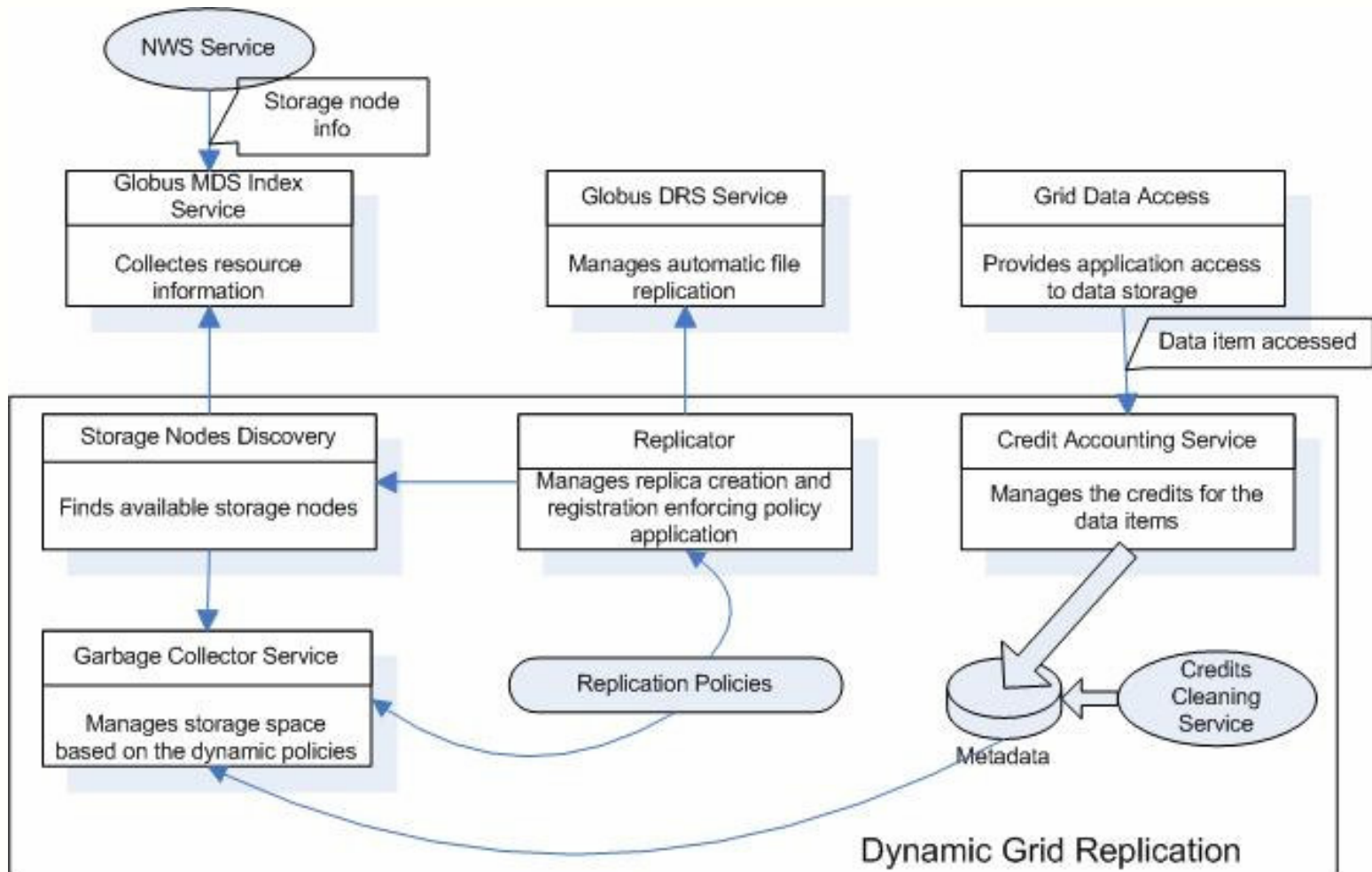


GENERIS component

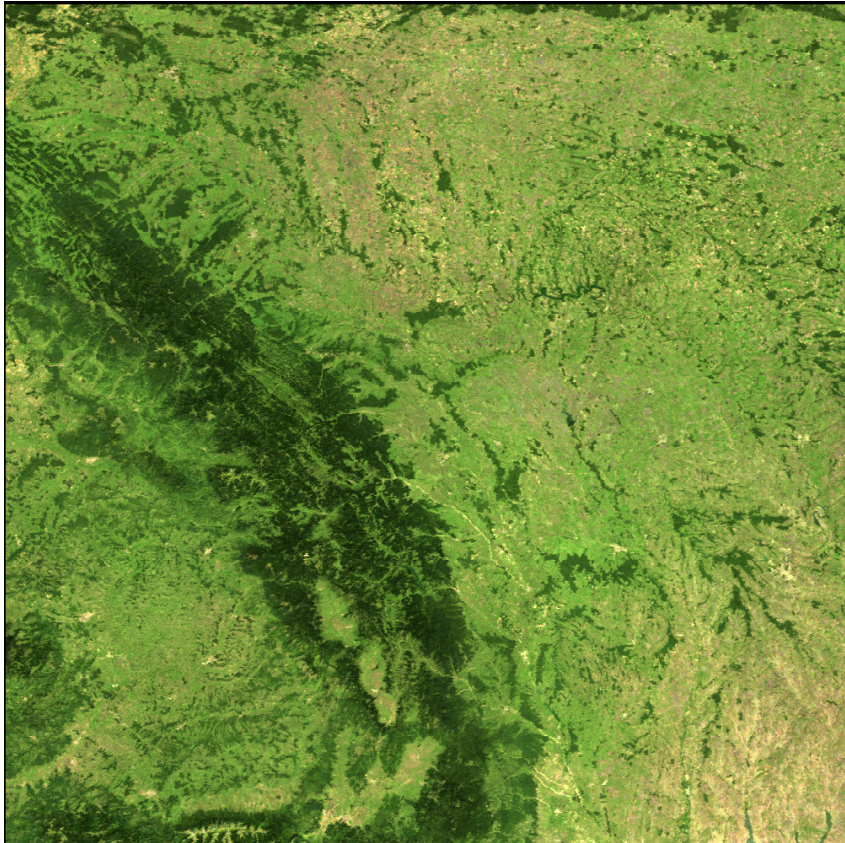
GENERIS (Grid based ENvironmEnt Representation and Information Service)



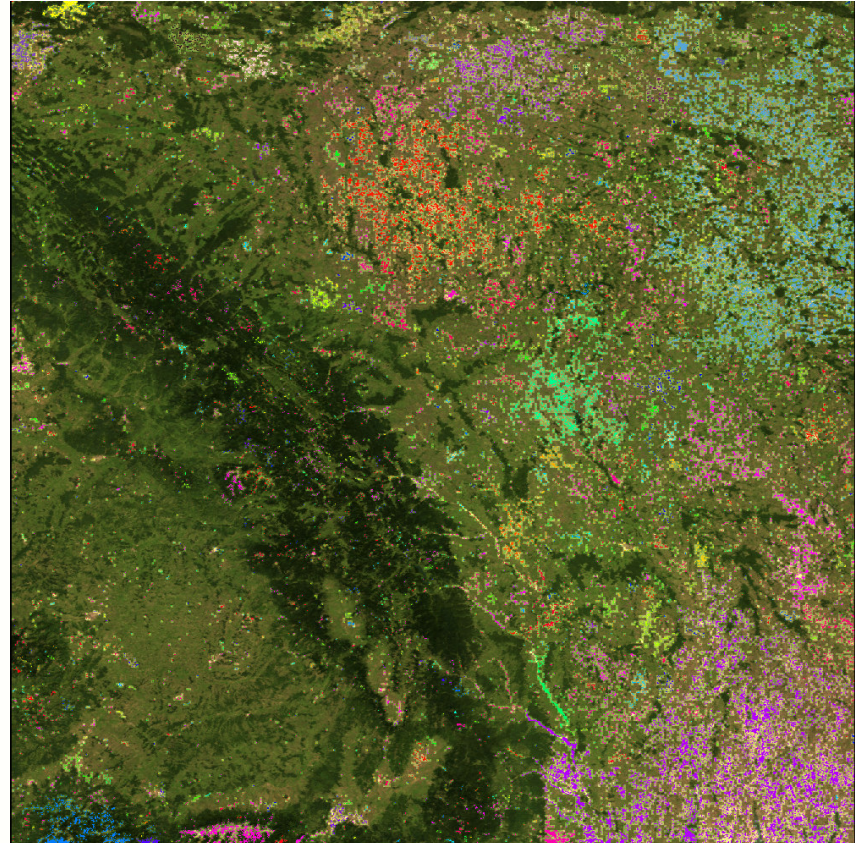
Data replication



Change detection

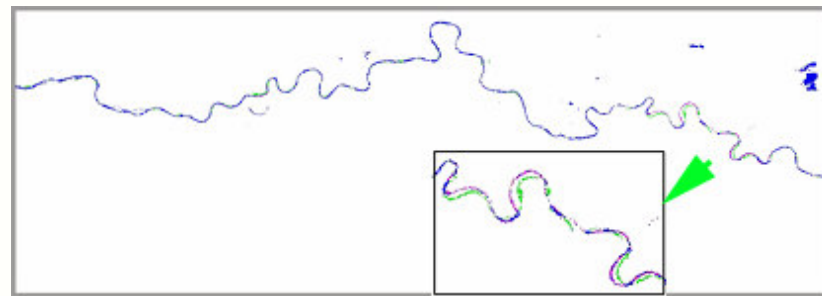
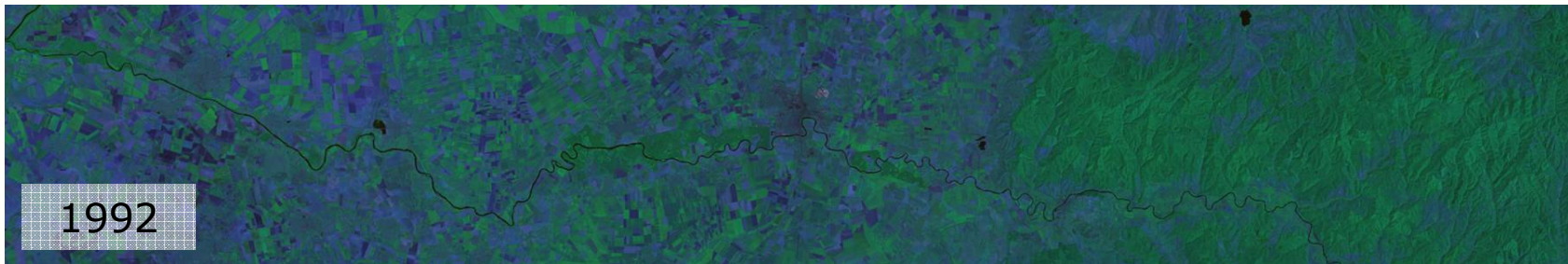


2004



2005, with changes

Change detection



Satellite image classification and segmentation

Classification using decision trees

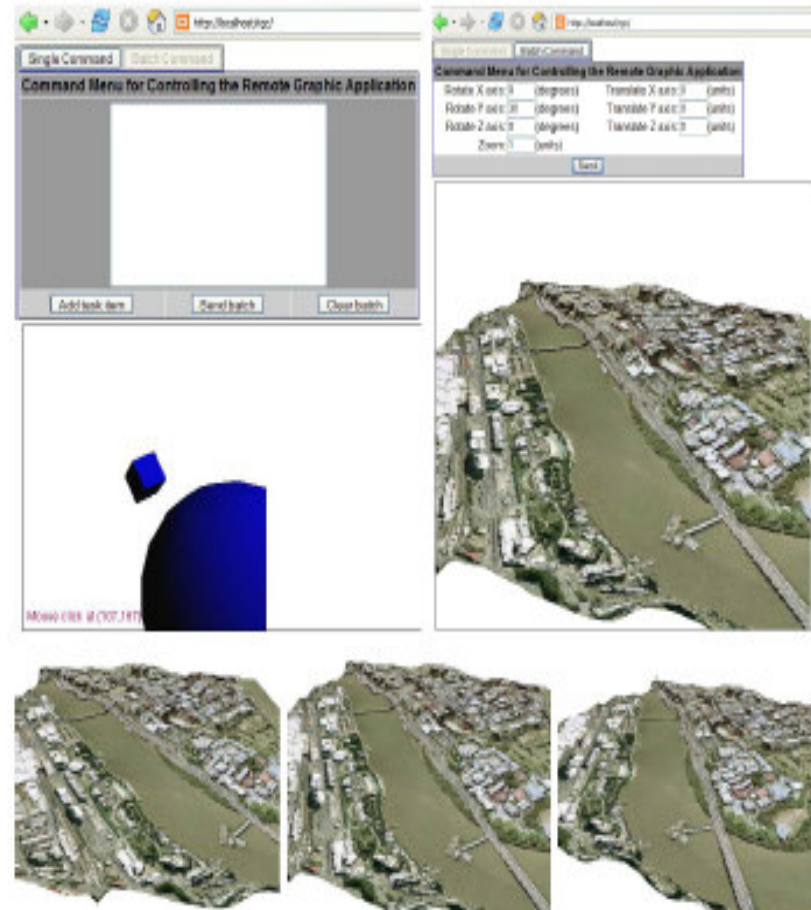
```
1 for y=0, height-1 do
2   for x=0, width-1 do
3     r,g,b = get_rgb (x,y)
4     if g<0.12 then
5       -- water -> blue
6       r=0.0 g=0.0 b=1.0
7     else
8       if r>0.4 then
9         -- cloud -> white
10        r=1.0 g=1.0 b=1.0
11      else
12        if r>0.15 then
13          -- non-forest -> yellow
14          r=1.0 g=1.0 b=0.0
15        else
16          if r<0.088 then
17            -- forest -> dark green
18            r=0.0 g=1.0 b=0.0
19          else
20            -- scrub -> brown
21            r=0.83 g=0.54 b=0.26
22          end
23        end
24      end
25    end
26    set_rgb (x,y,r,g,b)
27  end
28  progress (y/height)
29 end
```

using K-means

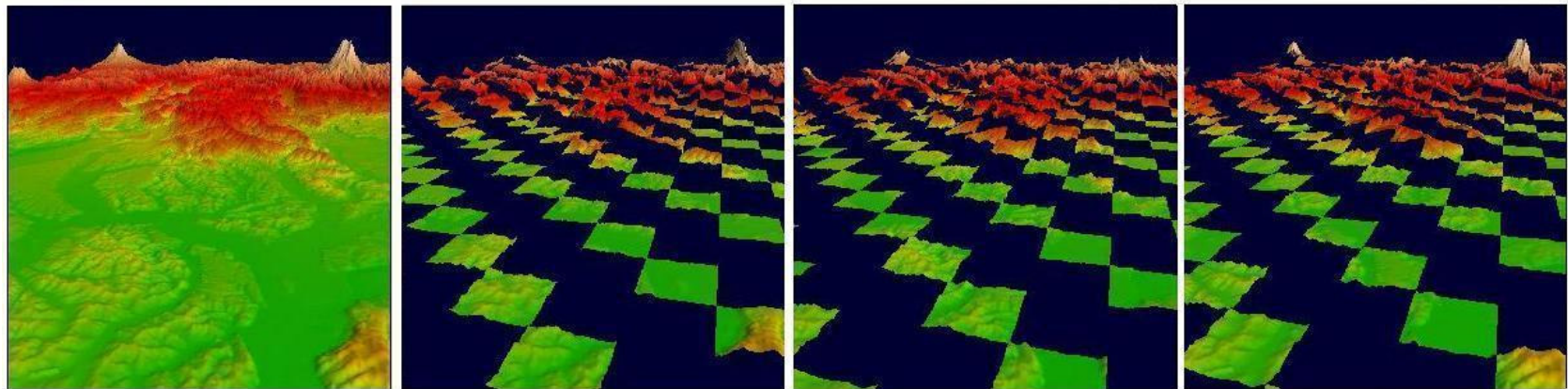
using Vegetation indices



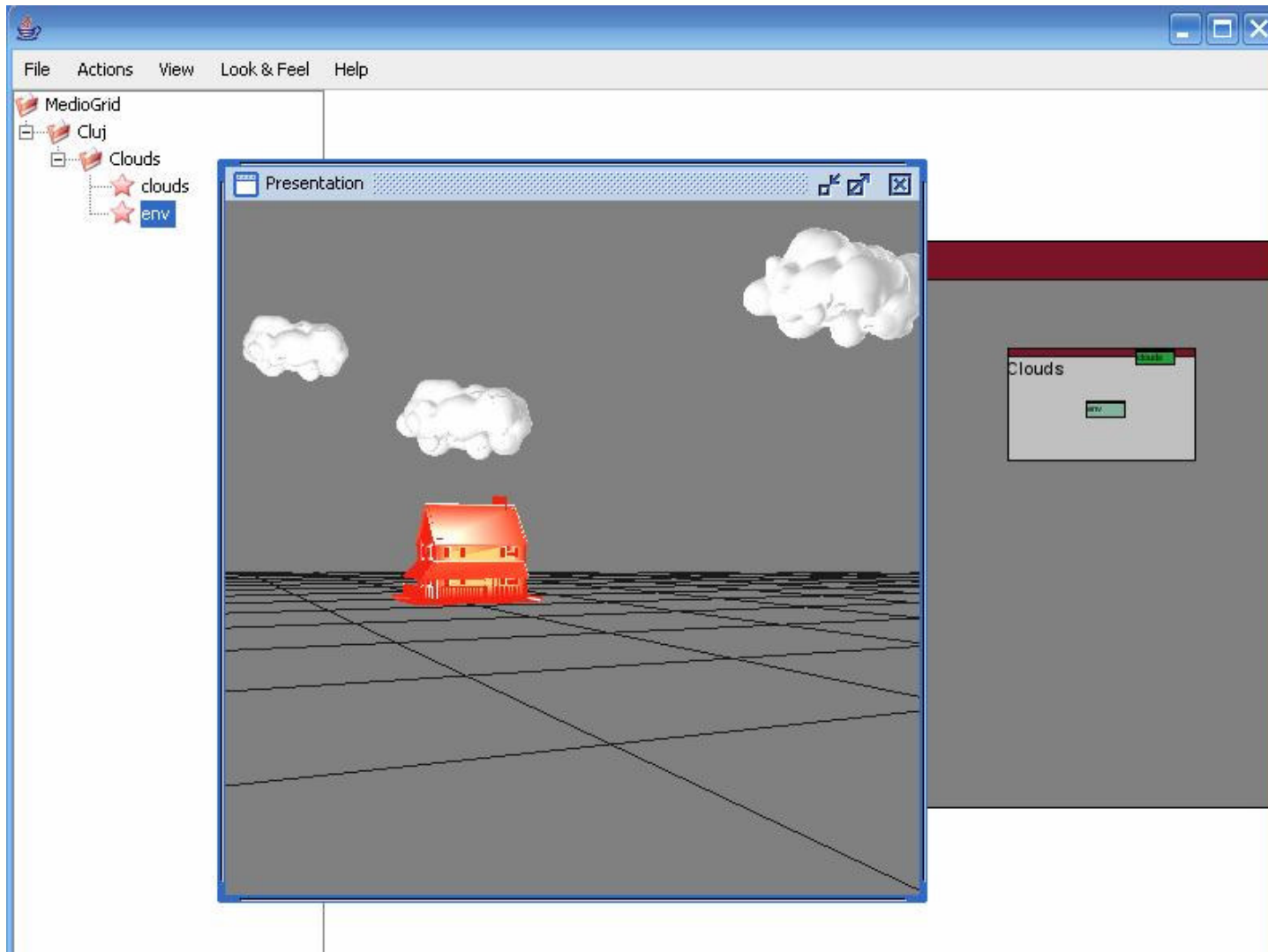
Remote control for graphic applications



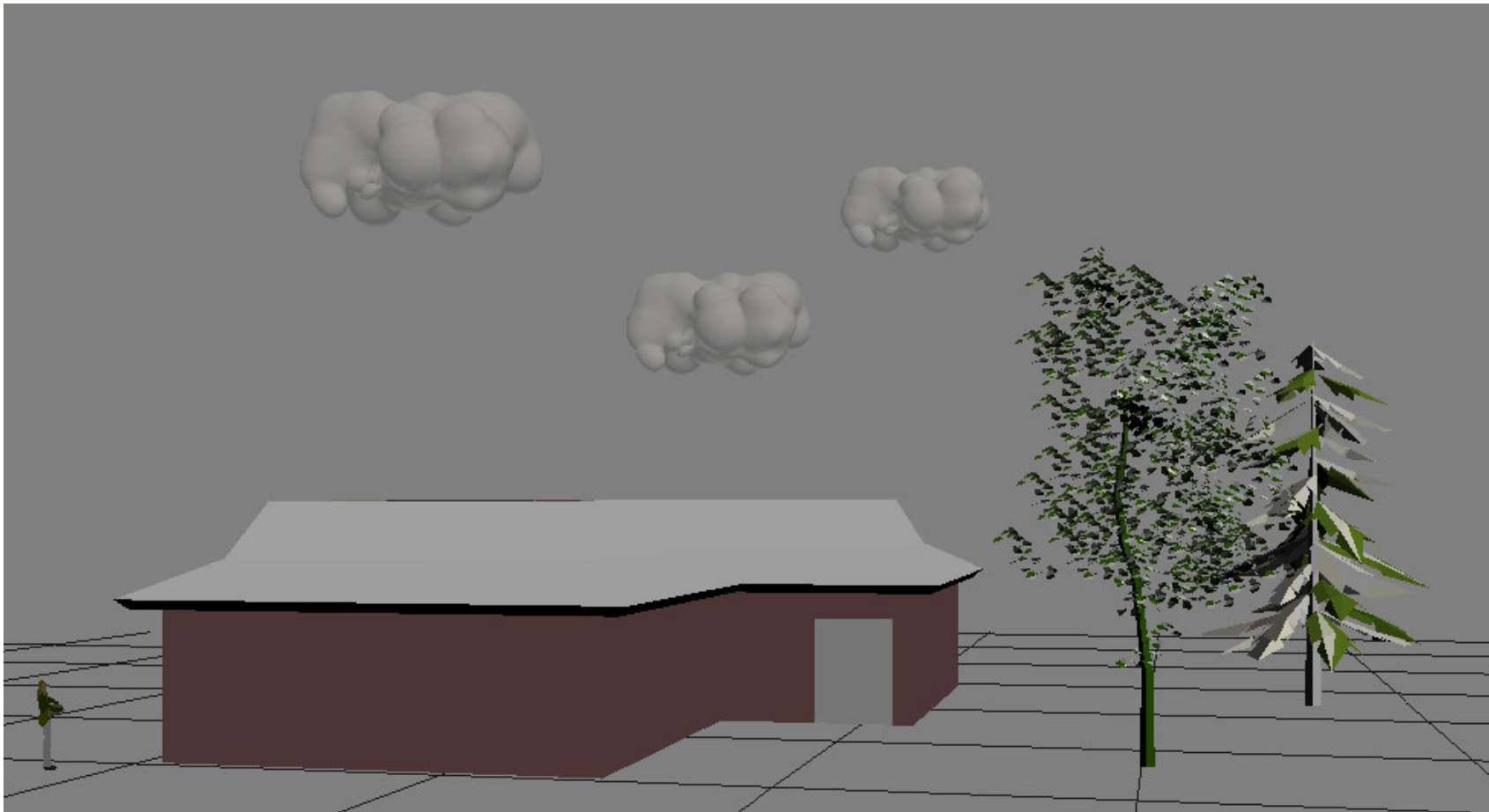
Parallel terrain rendering



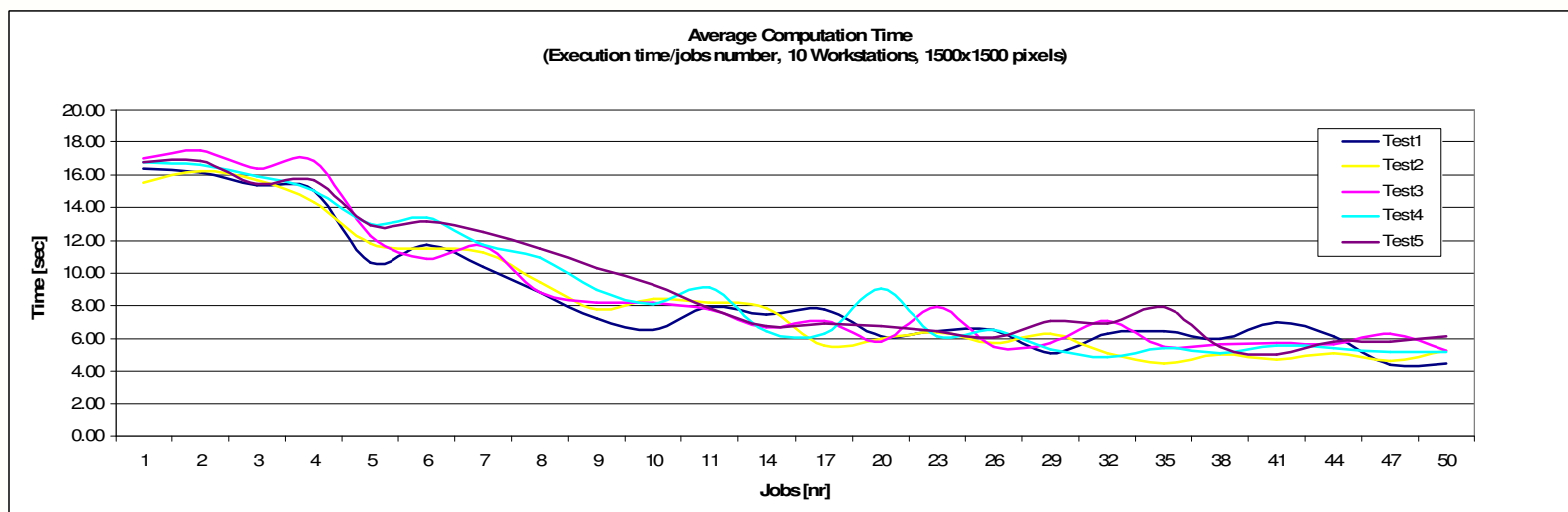
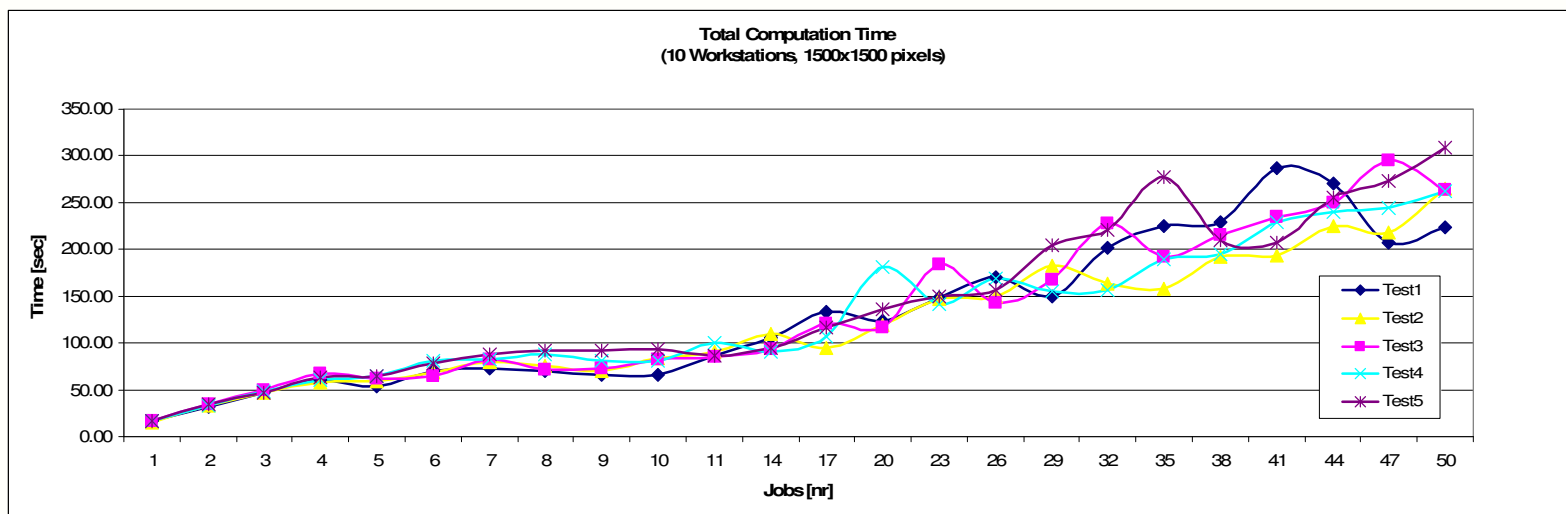
Virtual geographical space modeling



Virtual space visualization



Performance evaluation



Performance evaluation

- Execution time / job on 1 workstation:

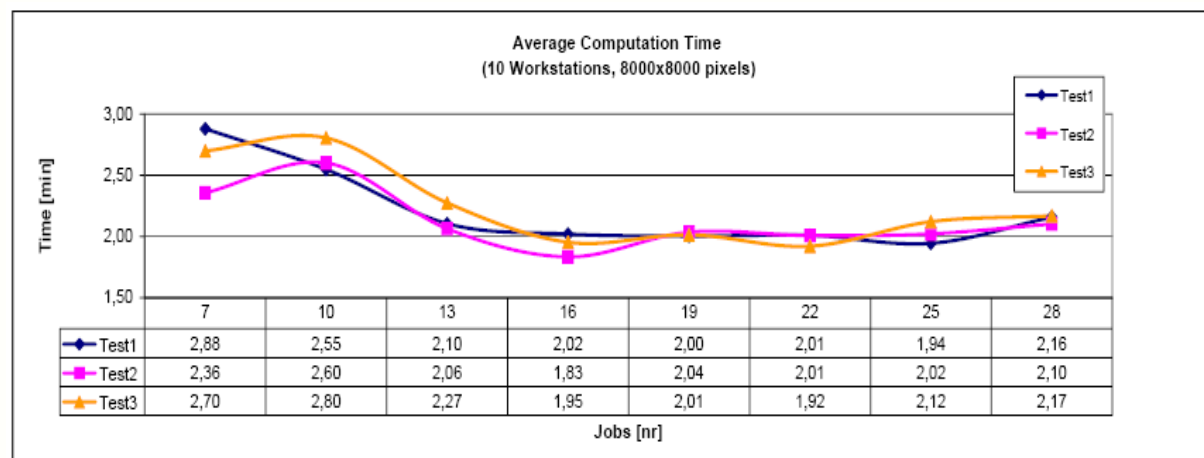
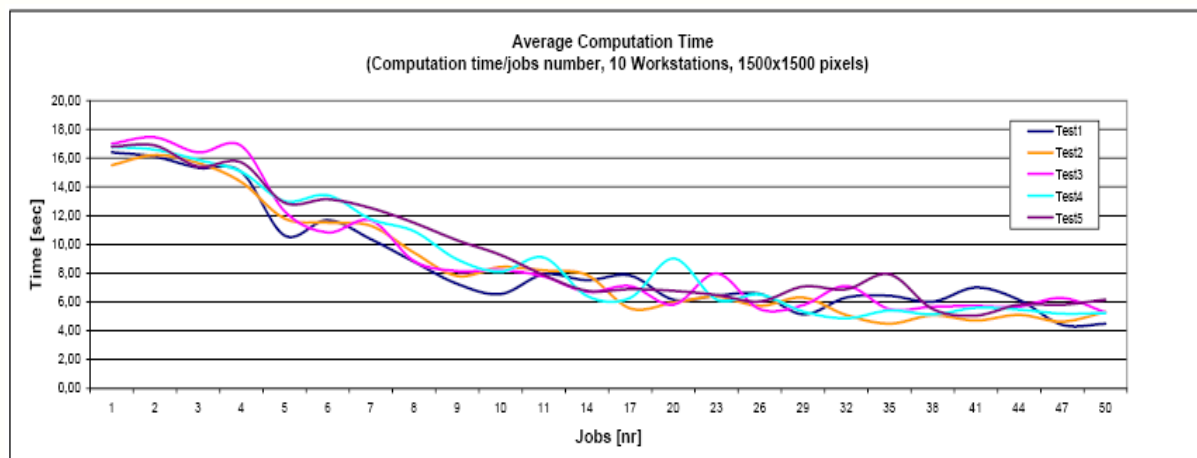
17 sec for image of 1500x1500 pixels

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



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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