MINISTRY OF EDUCATION AND RESEARCH

TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

CGIS Computer Graphics and Interactive Systems

Earth Science Oriented Applications
in CGIS Laboratory

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Specific Technical Objectives

- Explore huge spatial data (i.e. satellite images) to supply information on the earth surface, weather, clime, geographic areas, pollution, and natural phenomena
- Support many variables based processing - satellite image type (e.g. MODIS, Landsat), geographic area, soil composition, vegetation cover, season, and context (e.g. clouds)
- Develop tools and components to support the development of Distributed Architecture (i.e. HPC, Grid and Cloud) based EO (Earth Observation) applications
- Develop and experiment the EO Application Development Methodology
- Flexible description, instantiation, scheduling and optimal execution of the Grid processing

Computer Graphics and Interactive Systems Lab

- Computer Graphics and Interactive Systems Laboratory (CGIS) carry out research in computer graphics, Grid computing, spatial data modeling and processing, distributed interactive systems, graphic cluster based processing
- Develops Grid oriented tools, platforms and applications

  gSWAT, gSWATSim

  GreenLand v3

  eGLE

  ESIP, gProcess

  GreenView

  Greenland v1, Waterland, and Minerals applications
- Involved in enviroGRIDS VO, EGEE GEAR VO, SEE-GRID VO, Ro-GRID NGI
- Grid related research projects: enviroGRIDS, SEE-GRID-SCI, GiSHEO, mEducator, MedioGrid, COST IC0805

Grid Related Projects

- EnviroGRIDS, Black Sea Catchment Observation and Assessment System supporting Sustainable Development, FP7 project, co-funded by the European Commission (2009 - 2013).

- mEducator, Multi-type Content Repurposing and Sharing in Medical Education, eContentplus/ Digital Content and Cognitive Systems Programme. Funded by the European Commission (2009-2012).

- GiSHEO, On demand Grid services for high education and training in Earth Observation, ESA-PECS project , Funded by European Space Agency through PECS Programme (2008-2010).

- SEE-GRID-SCI, SEE-GRID eInfrastructure for regional eScience, FP7 project, co-funded by the European Commission (2008 - 2010).

- MEDIOGRID, Parallel and distributed graphical processing on grid structure of geographical and environmental data. CEEX National Project (2005-2008).

Computing Resources in enviroGRIDS VO

CGIS Computer Graphics and Interactive Systems

- UTCN (Technical University of Cluj-Napoca)

  RO-09-UTCN, 128 quad-core (512 core processors), and 12 TB.

- UVT (West University of Timisoara)

  RO-08-UVT, joins the enviroGRIDS VO by 10 Working Nodes (WN) (CPU: 1.6 GHz Core2Duo, RAM: 2GB/node, HDD: 160GB, Network: 1Gbps, Services: MPI_WN); One Storage Element (SE) of 800GB.

- UPB (University Politehnica of Bucharest)

  RO-03-UPB, 386 physical core processors, storage of 40 TB.

- ICI (National Research Institute in Informatics)

  RO-01-ICI, has 12 WN in production (gLite), and SE of 1 TB.

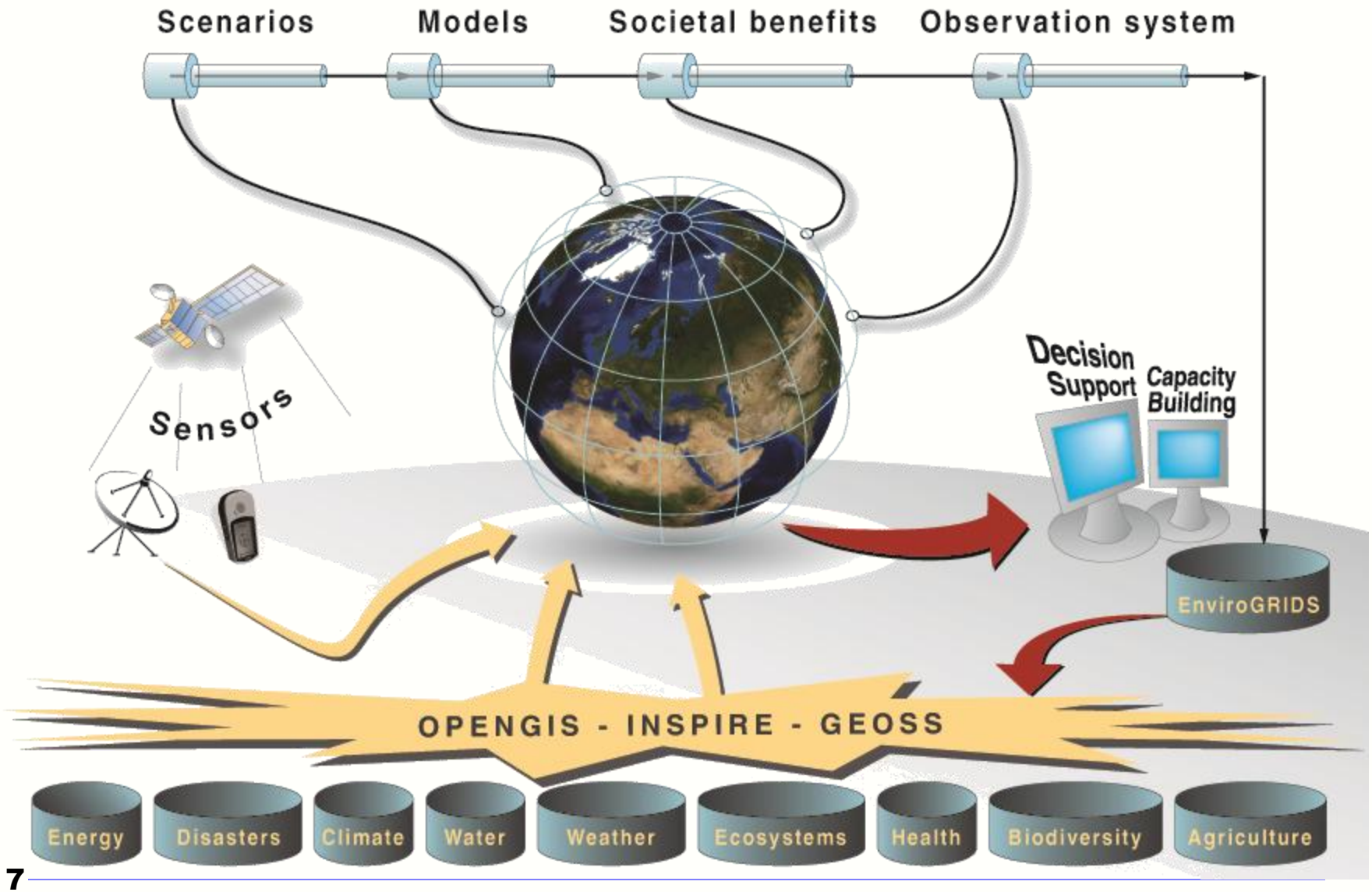
enviroGRIDS Project

- **EnviroGRIDS** - Gridifying the Black Sea catchment to support its sustainable development
  http://www.envirogrids.net/

- Founded by the European Commission FP7 framework (Theme 6: environment), April 2009 – March 2013
  27 partners, 7.9 mil EUR.

- Coordinator
  - University of Geneva, Switzerland

enviroGRIDS Project



Building Capacity for a Black Sea Basin Observation and Assessment System supporting Sustainable Development

Map source: "Eutrophication in the Black Sea region; impact assessment and causal chain analysis", Global International Waters Assessment (GIWA).

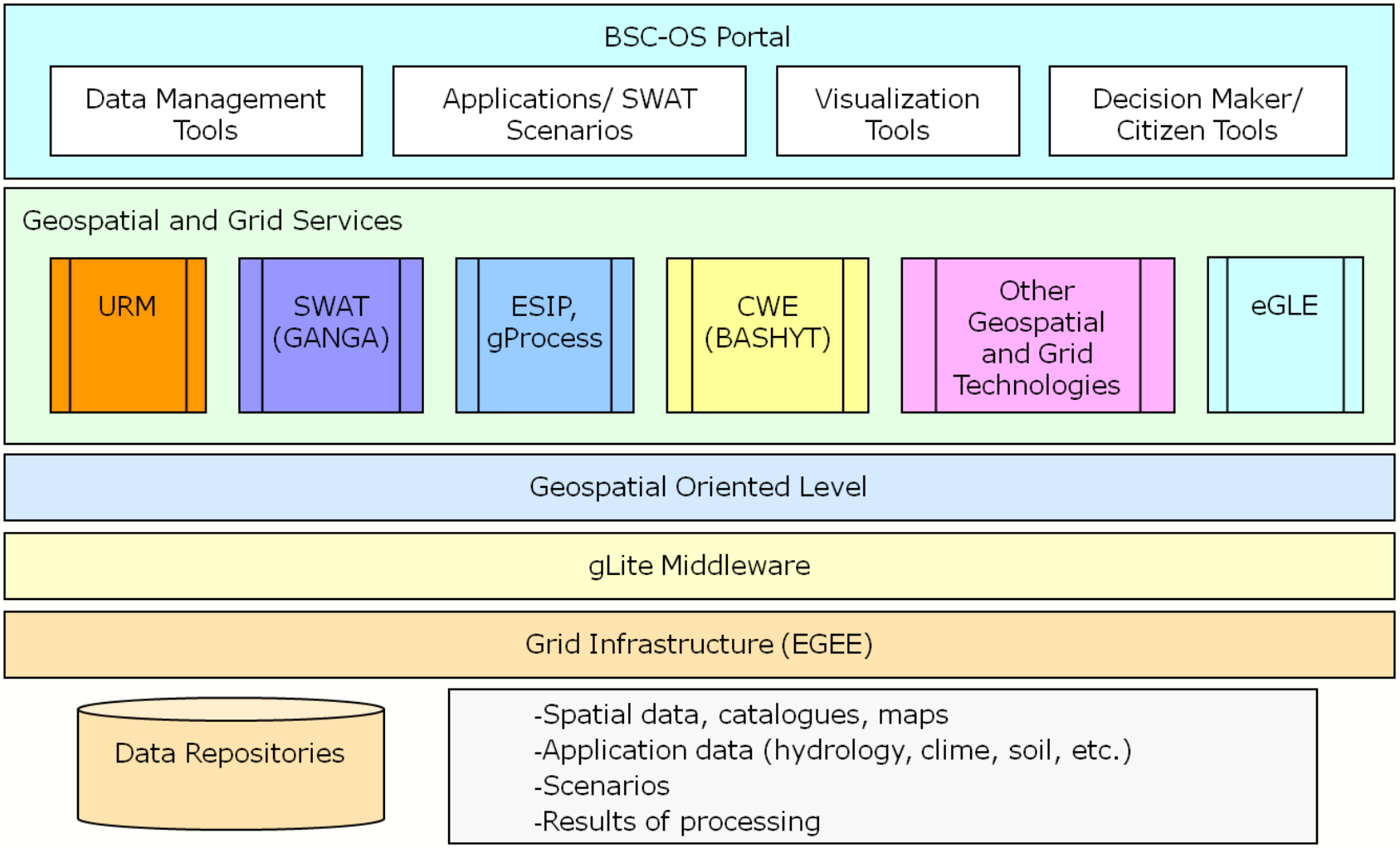
enviroGRIDS – General Objectives

- Gap analysis
- Spatially explicit regional scenarios of development
- Modeling of large scale, high resolution distributed hydrologic processes
- Develop access to real time data from sensors and satellites
- Streamlining the production of indicators on sustainability and vulnerability of societal benefits
- Develop early warning and decision support tools at regional, national and local levels
- Build capacities in the implementation of many new standards and frameworks

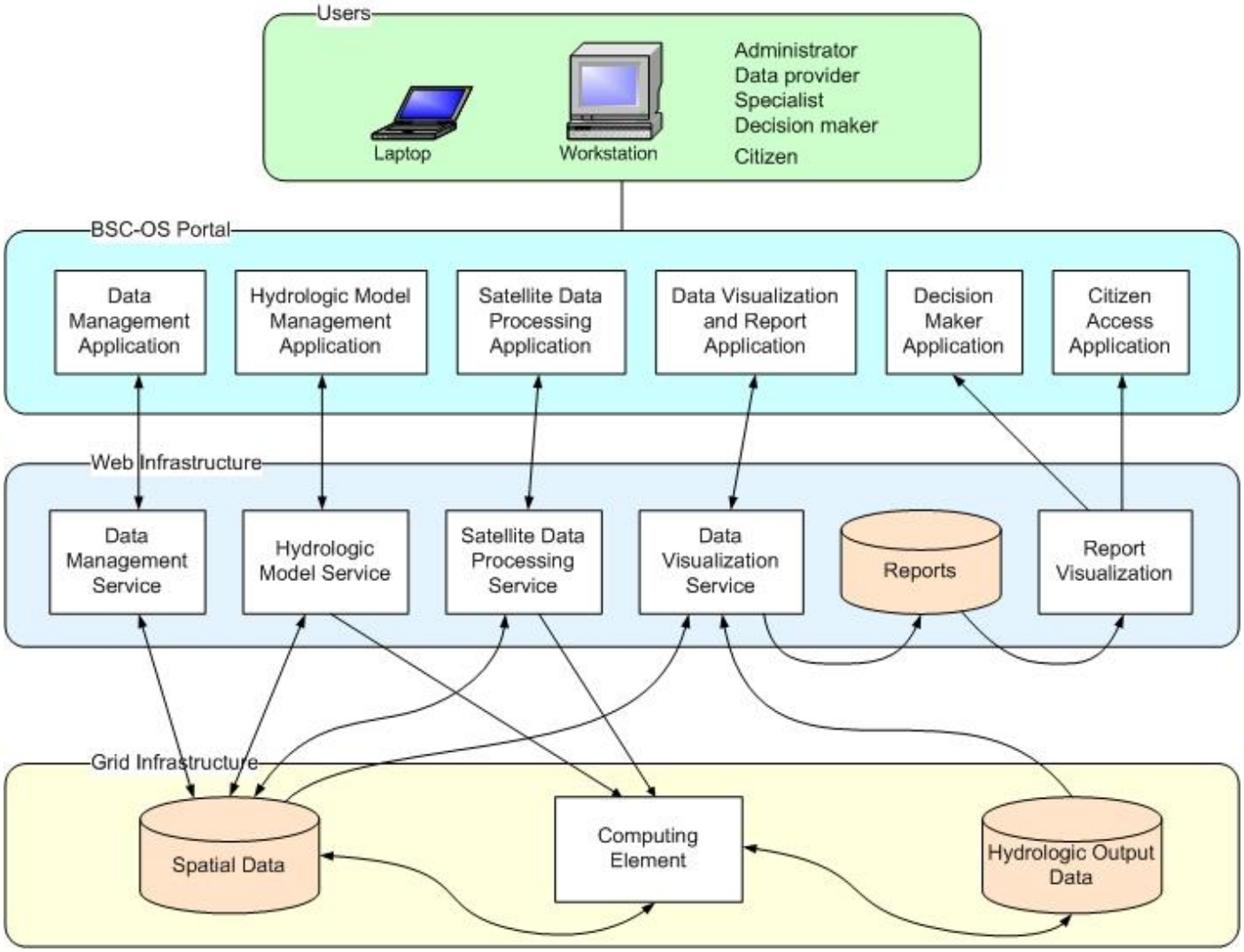
BSC-OS Portal

- Single way of the user to get into the enviroGRIDS system
- Exposes personalized tools for different category of users: data manager, earth science specialist, decision maker, citizen, and system administrator.
- Provide applications for:
  - data management
  - hydrologic models calibration and execution
  - satellite image processing
  - report generation and visualization
  - virtual training center
- Support interoperability between the Geospatial and Grid infrastructures on security, heterogeneous data access, distributed data processing
- EnviroGRIDS functionality gathers services provided by various technologies such as SWAT related modules, Collaborative Working Environment (CWE), Uniform Resource Management (URM), gProcess, ESIP, and eGLE platforms

Portal Architecture



Data Flow Throughout the Portal

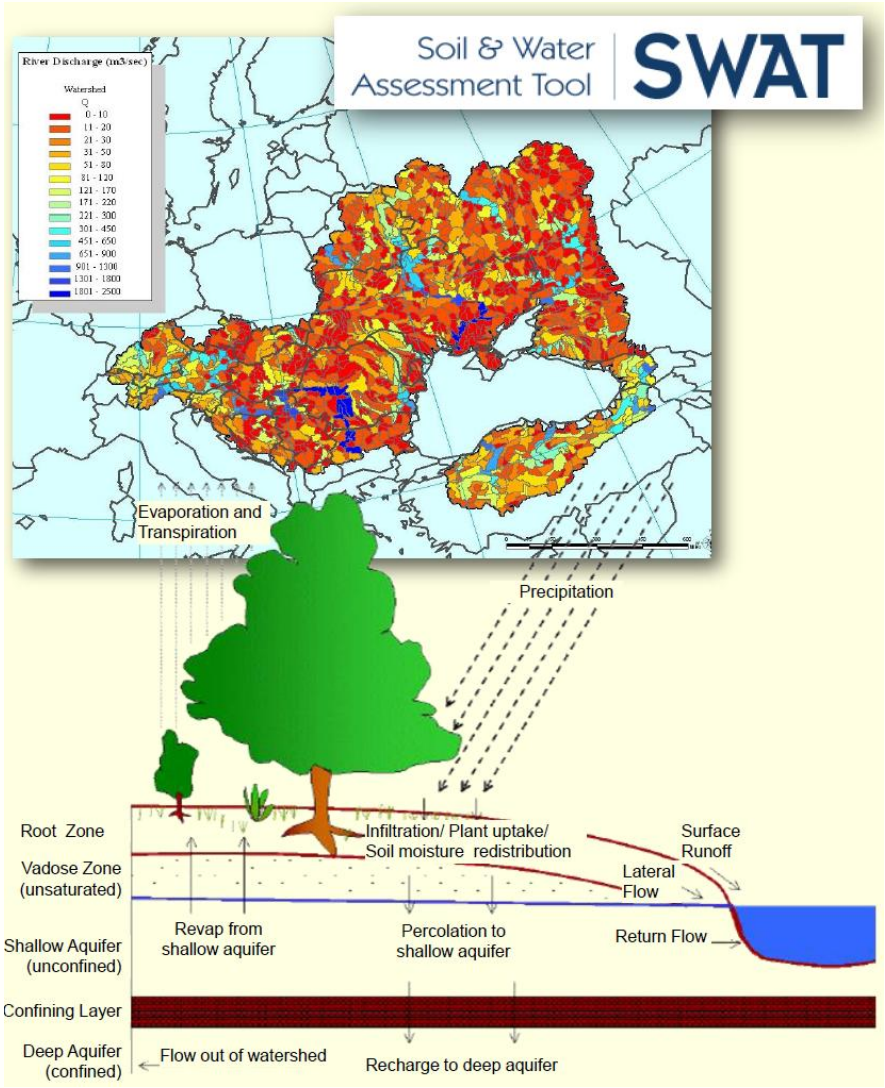


Specific Objectives

- Link, gather, store, manage and distribute key environmental data concerning the Black Sea Catchment Basin
- Large scale and high resolution distributed hydrological models
- Gridification of tools and applications
- Model and process huge spatial data over the Grid (e.g. hydrological models, satellite images, and maps)
- Develop early warning and decision support tools at regional, national and local levels

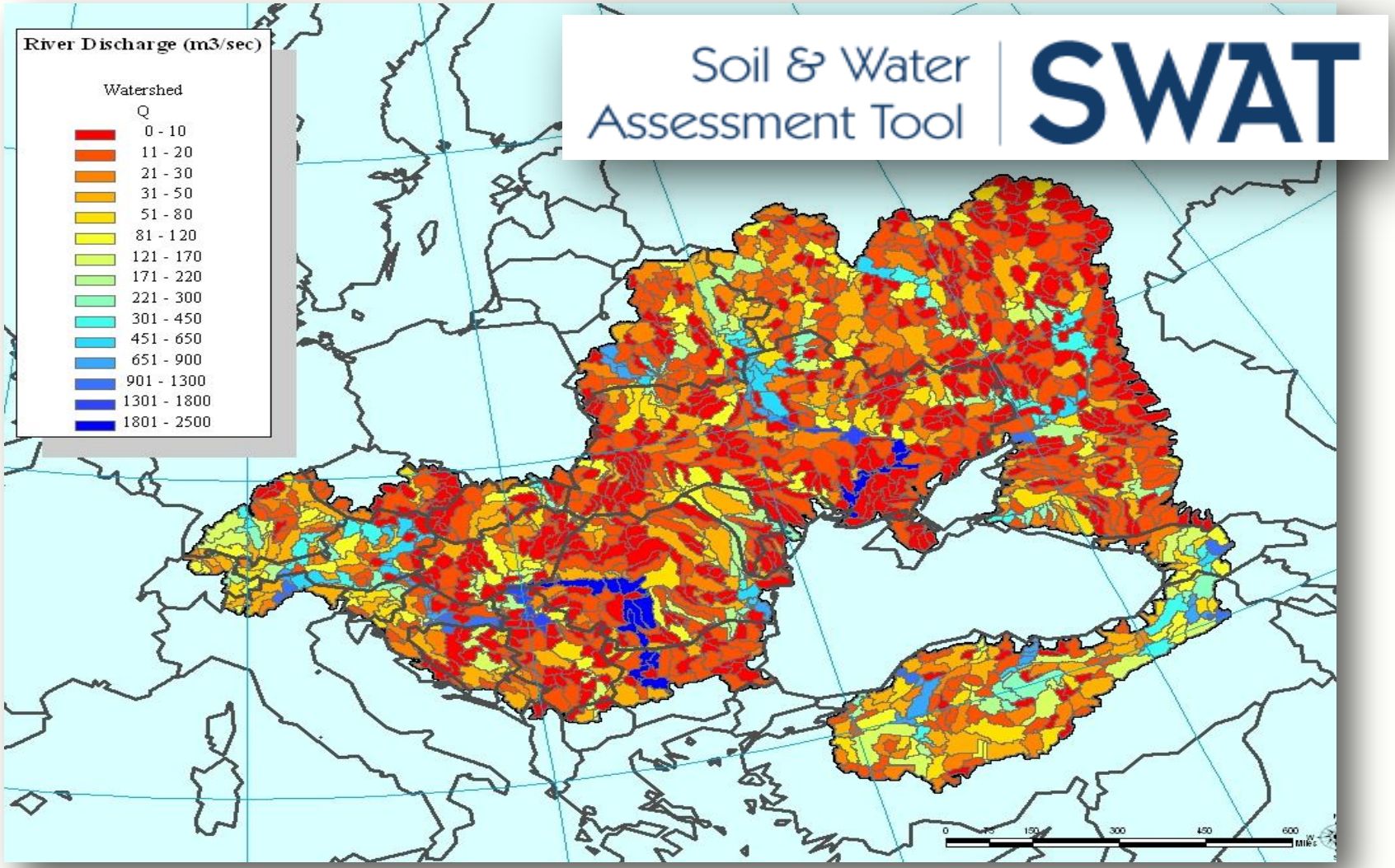
Hydrological Models - SWAT

- SWAT (Soil Water Assessment Tool)
  - hydrological model
  - operates on a daily time step
  - used for predicting the water resources, sediment, and chemical yields in a specific watershed
- Input data: weather, soil properties, topography, vegetation, and land management practices of the watershed
- SWAT estimates the impact of land management practices on water quantity and quality in complex watersheds
- The SWAT model must pass through a careful calibration and uncertainty analysis



Black Sea Catchment Basin

CGIS
Computer Graphics and Interactive Systems



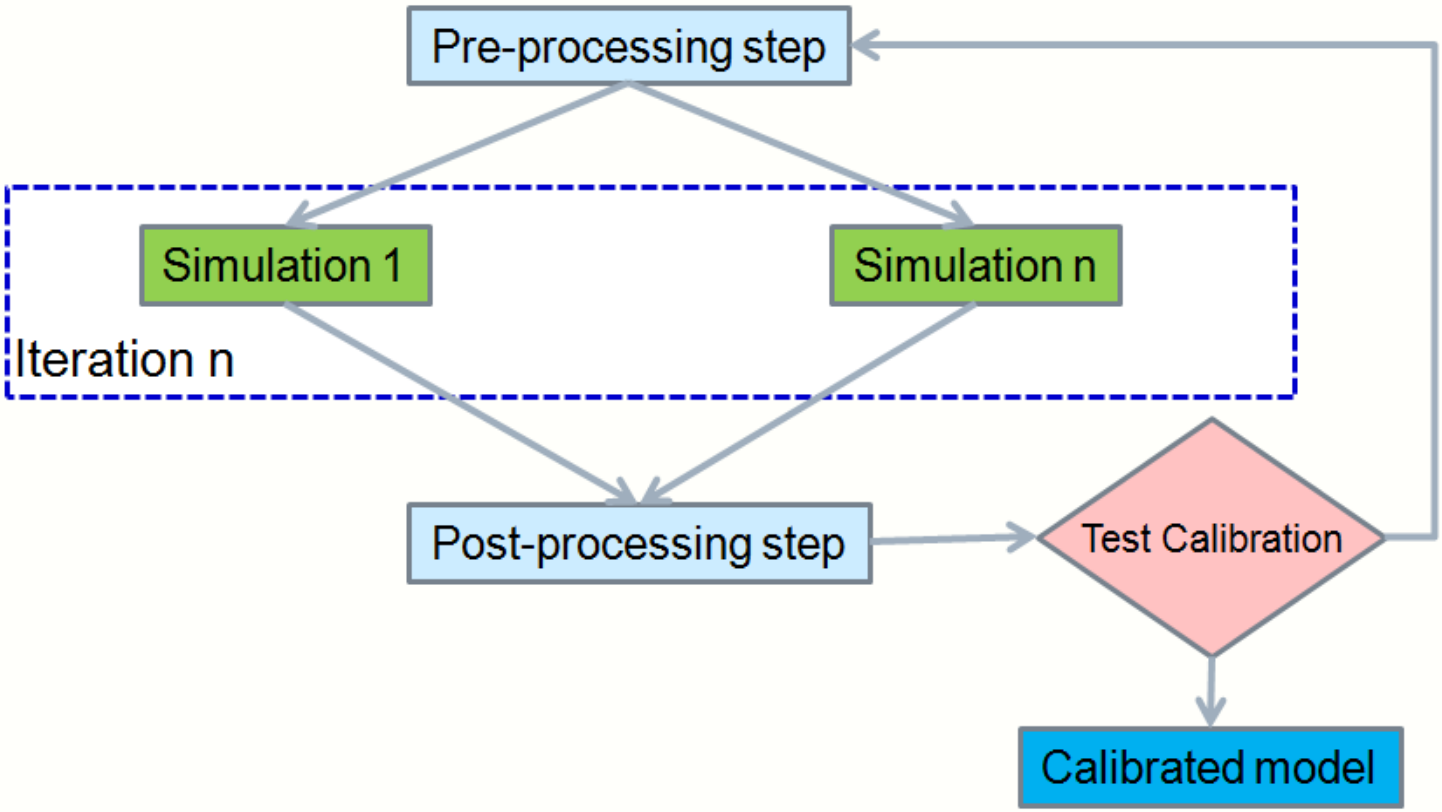
Grid Based Processing

- Many input data required by the SWAT model -> store the data on Storage Elements
- The calibration process requires running a high number of iterations, each iteration consisting in a high number of simulations -> execution on different Grid Worker Nodes
- Allows the calibration of the SWAT models and the execution of different scenarios based on a calibrated SWAT model on GRID infrastructures

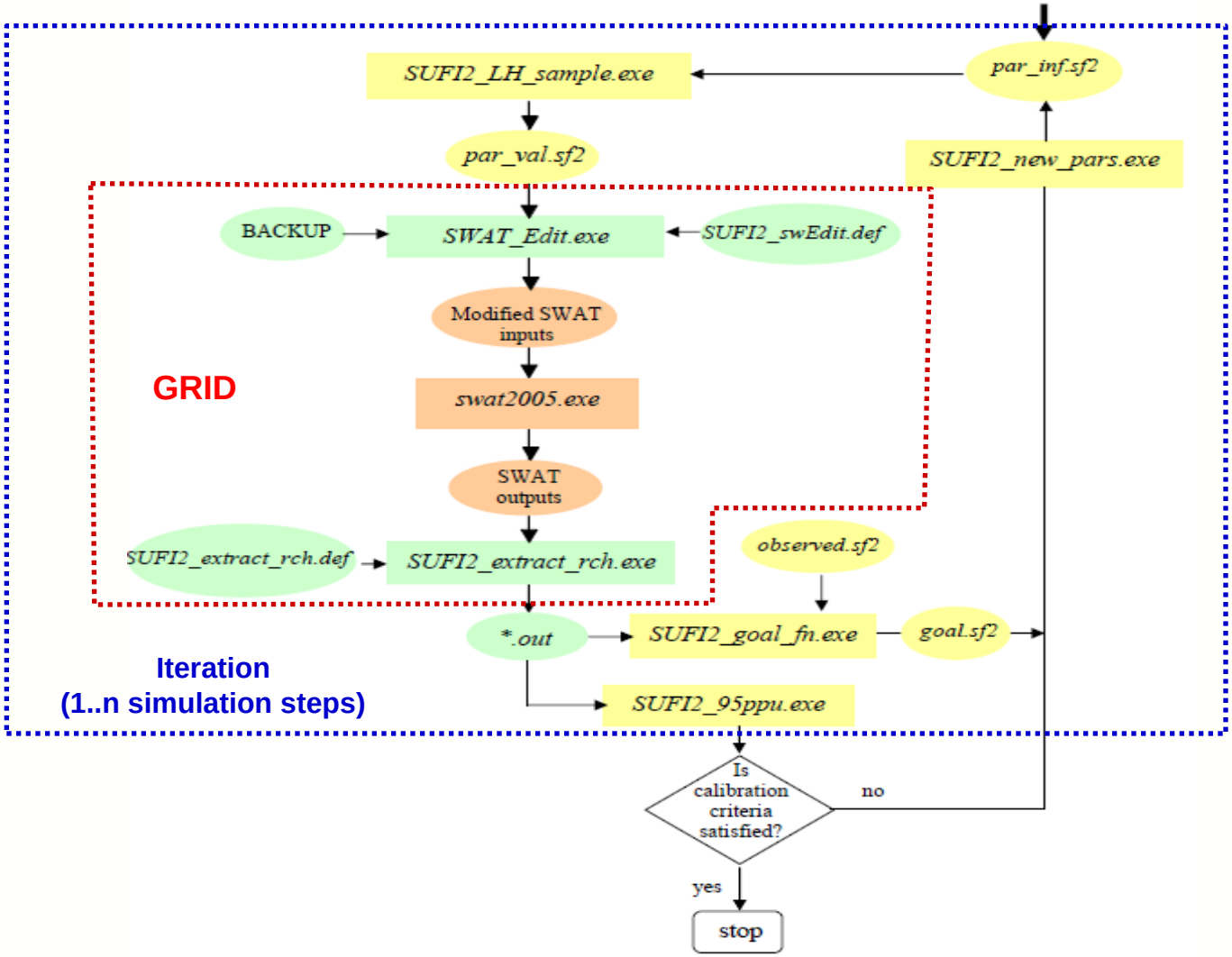
gSWAT Application

- Support the SWAT model development in the BSC-OS Portal
- Model calibration and execution over the Grid infrastructure
- Project management of the hydrological model
- SWAT data visualization
- Project upload and download
- Support interaction with visualization tools
- Support interaction with scenarios development tools

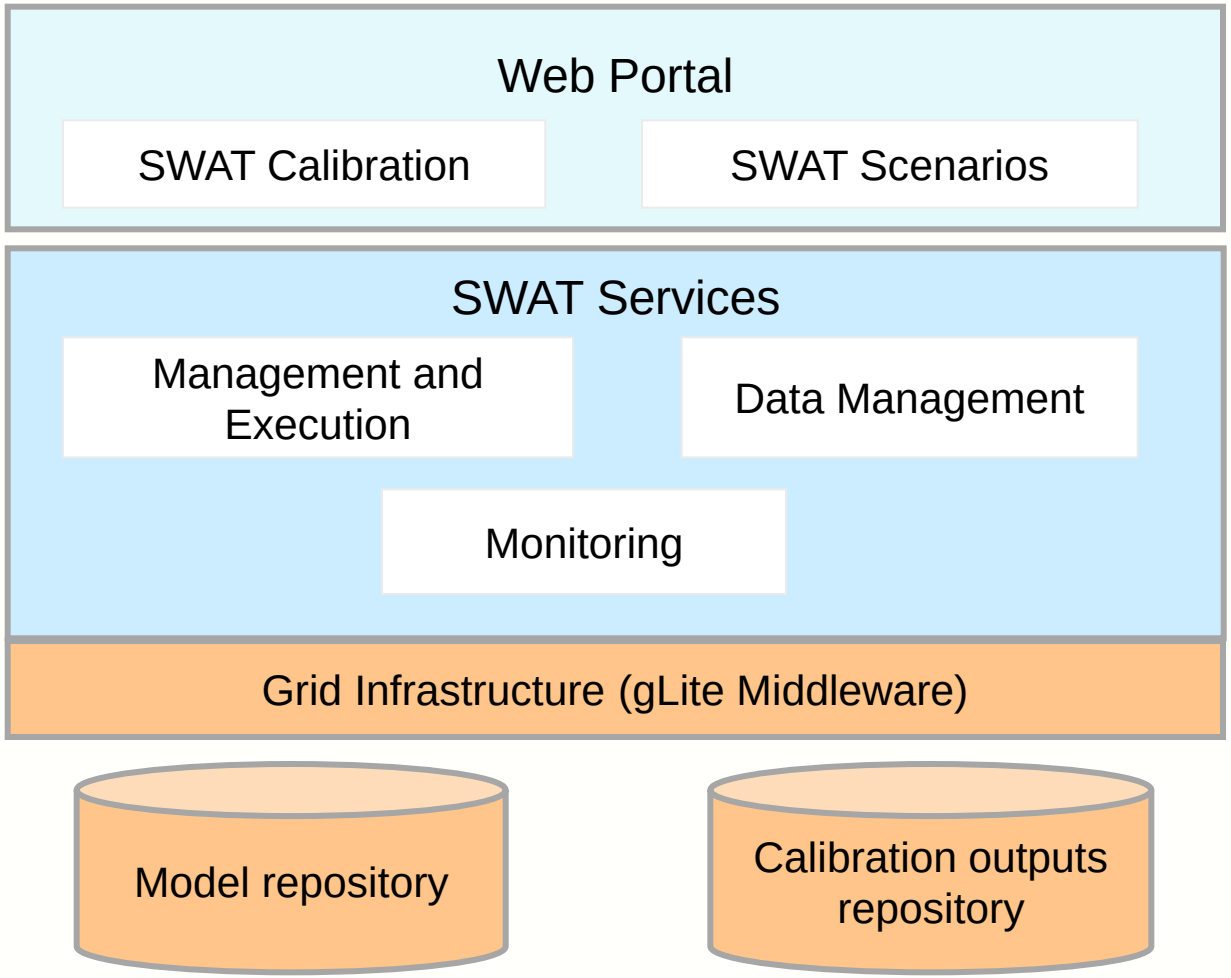
Processing Steps



Calibration Process



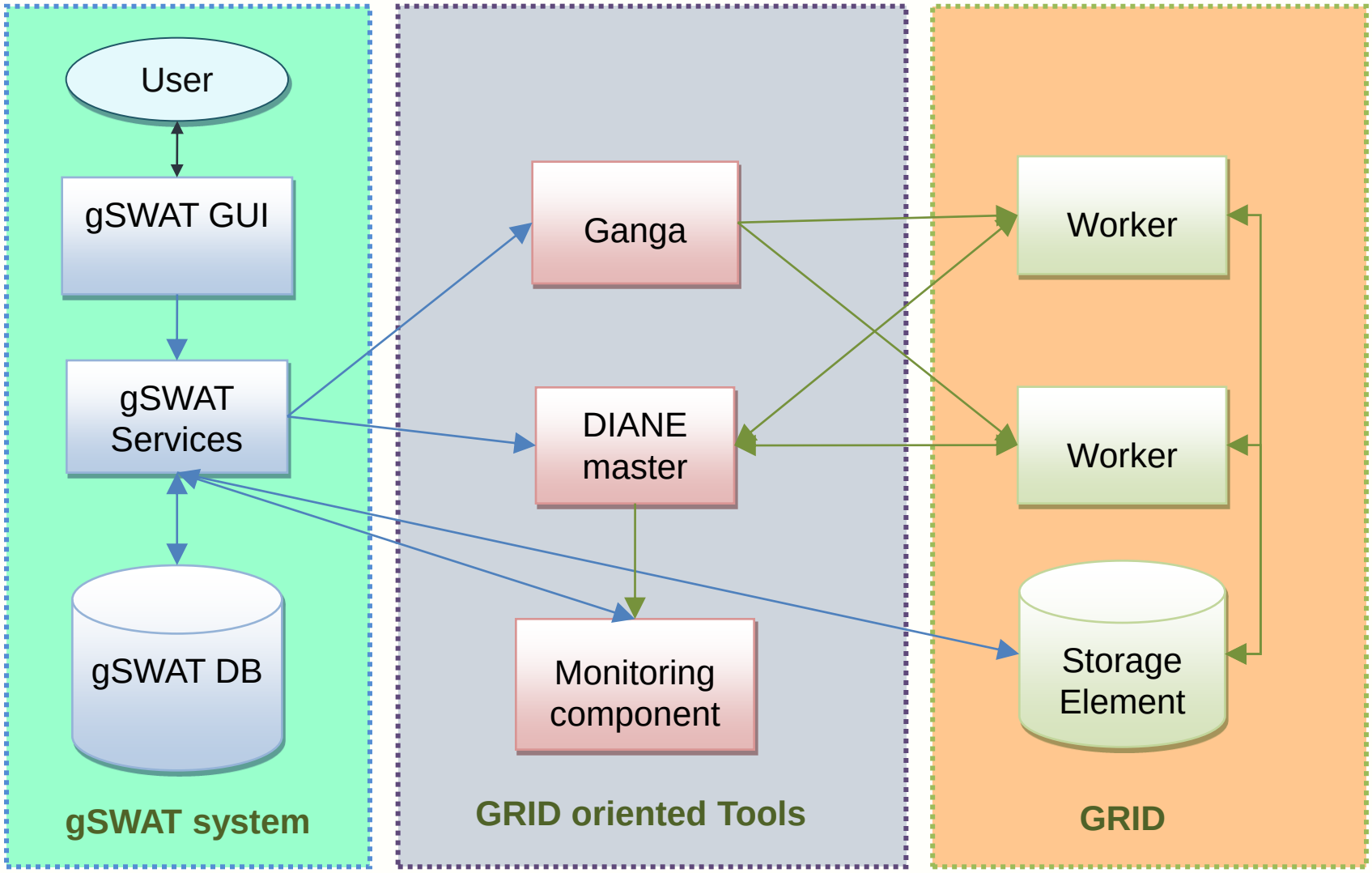
gSWAT Application - Architecture



gSWAT Execution Flow

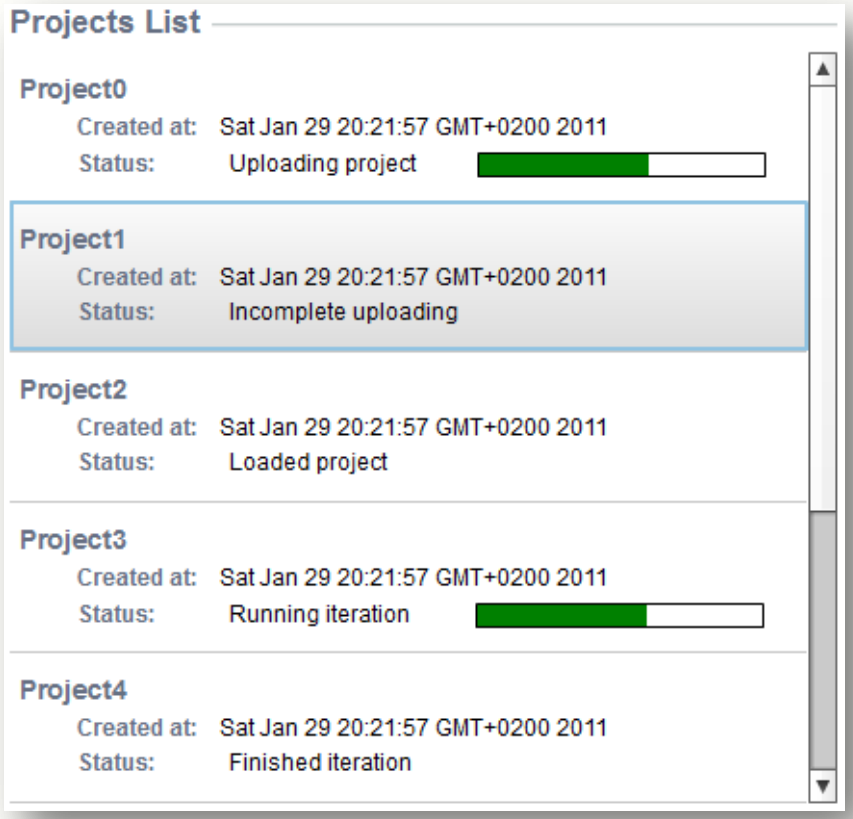
- **Create the job script** – the executable that will run on the Grid;
- **Create the DIANE script** –specifies the input data for each task (simulation). Each task will execute one simulation. DIANE will copy the input data on the worker node prior the start of the task executable;
- **Start the DIANE master** – for each iteration we start a new DIANE master;
- **Start the Grid workers using GANGA** – the workers will connect to DIANE master to receive the tasks to be processed;
- **Monitor the execution of the tasks (simulations)** – the monitoring data is retrieved and stored on the gSWAT database from where it can be visualized by the user;
- **Download the output data** – after all the tasks (simulations) are performed the output data is retrieved and stored locally at the gSWAT server side.

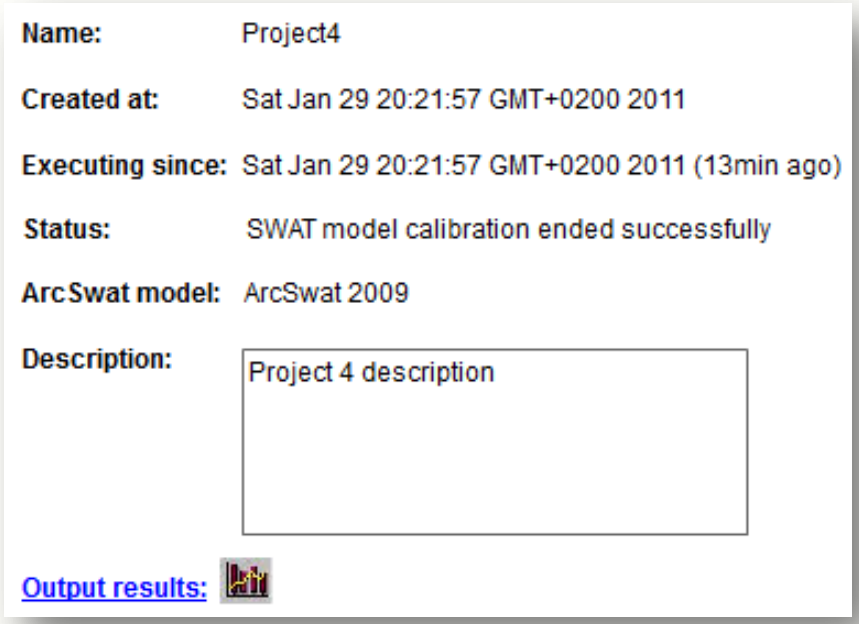
gSWAT Control Flow



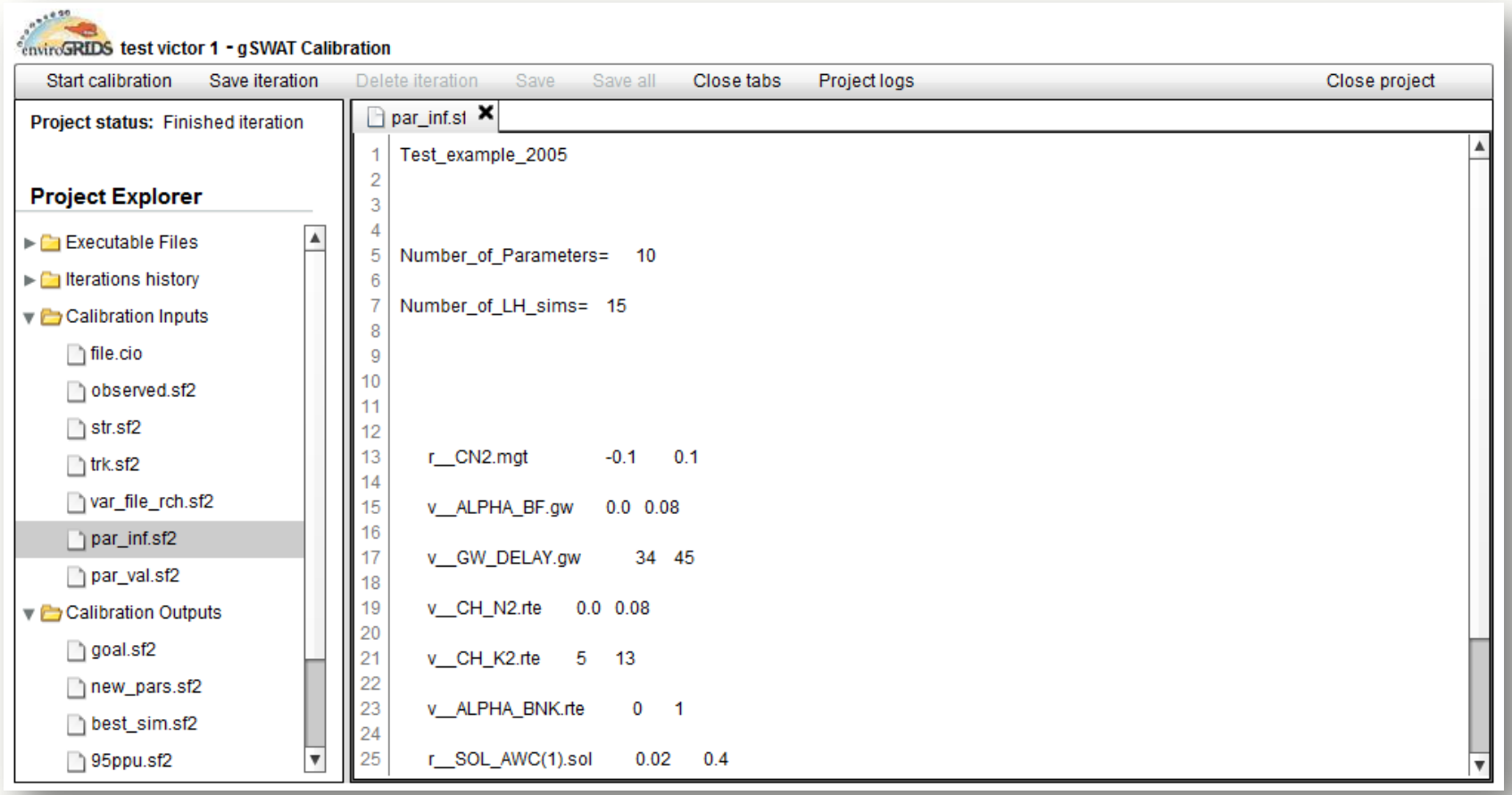
gSWAT User Interface

- Project list and detailed information on the selected project

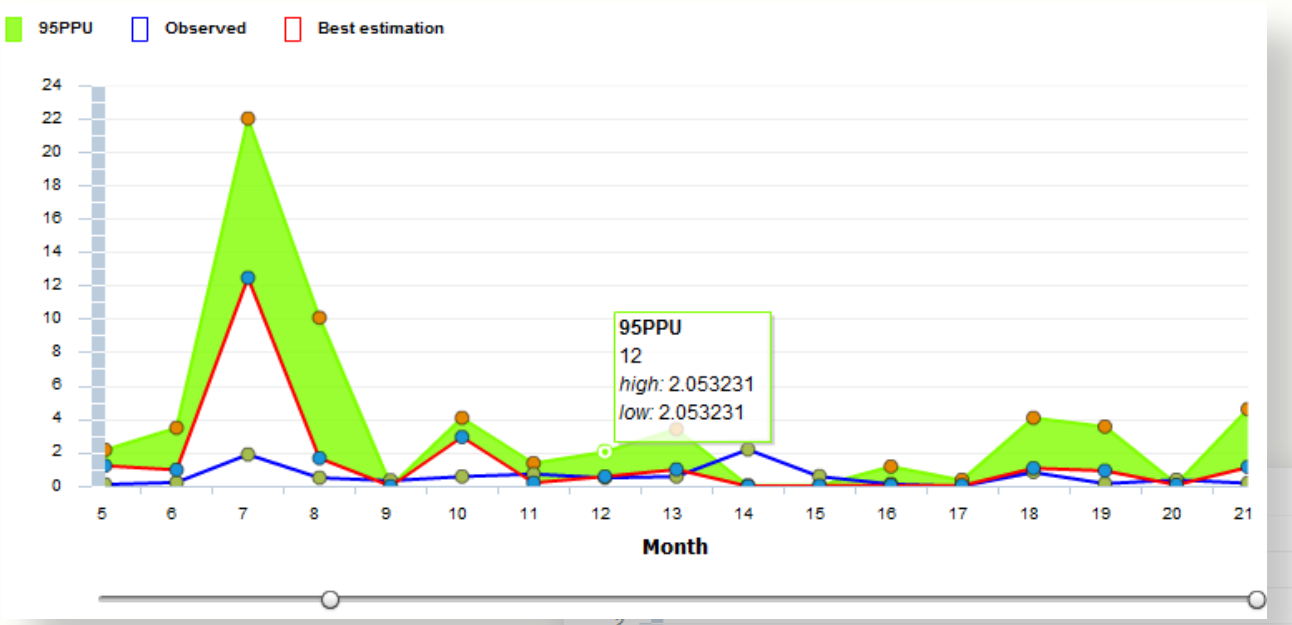


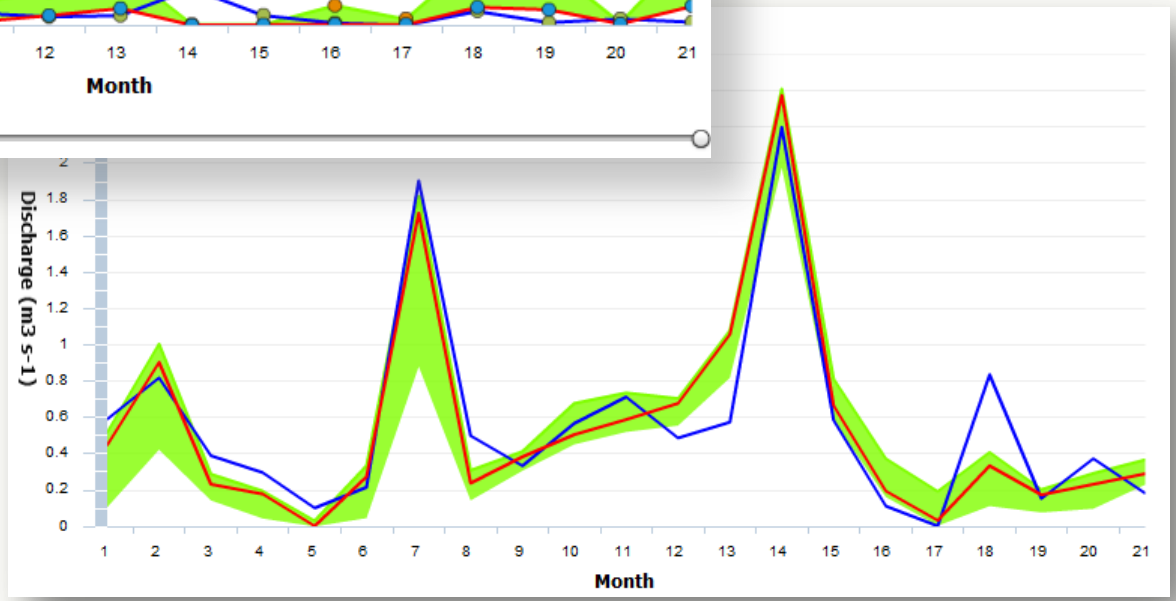


Modify SUFI2 Calibration Parameters



Calibration Output Visualization





gProcess and ESIP Platforms

- **ESIP** - Environment Oriented Satellite Image Processing Platform

  ESIP has been approved for endorsement by the **EGEE RESPECT Program**. The RESPECT program (Recommended External Software for EGEE Communities) aims to publicize grid software and services that work well in concert with the EGEE gLite software.

  ESIP demo is available at

  http://cgis.utcluj.ro/movie/ESIP.wmv

- based on the gProcess platform developed by the **MedioGrid** project.
- The **gProcess** toolset supports the flexible description, instantiation, scheduling and execution of the Grid processing.
- gProcess has been extended and ESIP developed through the SEE-GRID-SCI Project.

gProcess and ESIP Platforms

- The **gProcess** platform is a collection of Grid services and tools providing the following basic functionality:
  - Interactive description of the Grid based satellite image processing by pattern workflow
  - Development of hyper-graphs as a composition of basic operators, services, and sub-graphs
  - Pattern workflow instantiation for particular satellite image
  - Satellite data management, access and visualization
  - Workflow based Grid execution
- Wiki description of ESIP:
  - http://wiki.egee-see.org/index.php/JRA1_Commonalities

gProcess and ESIP Platforms

- **ESIP Platform** development, and Methodological Approach for **ESIP** based application development

  Partners: 1. Technical University of Cluj-Napoca (UTCN), ESIP coordinator

  2. National Center for Information Technology (NCIT) Bucharest

  3. West University of Timisoara (UVT)

  4. ICI Bucharest, national coordinator

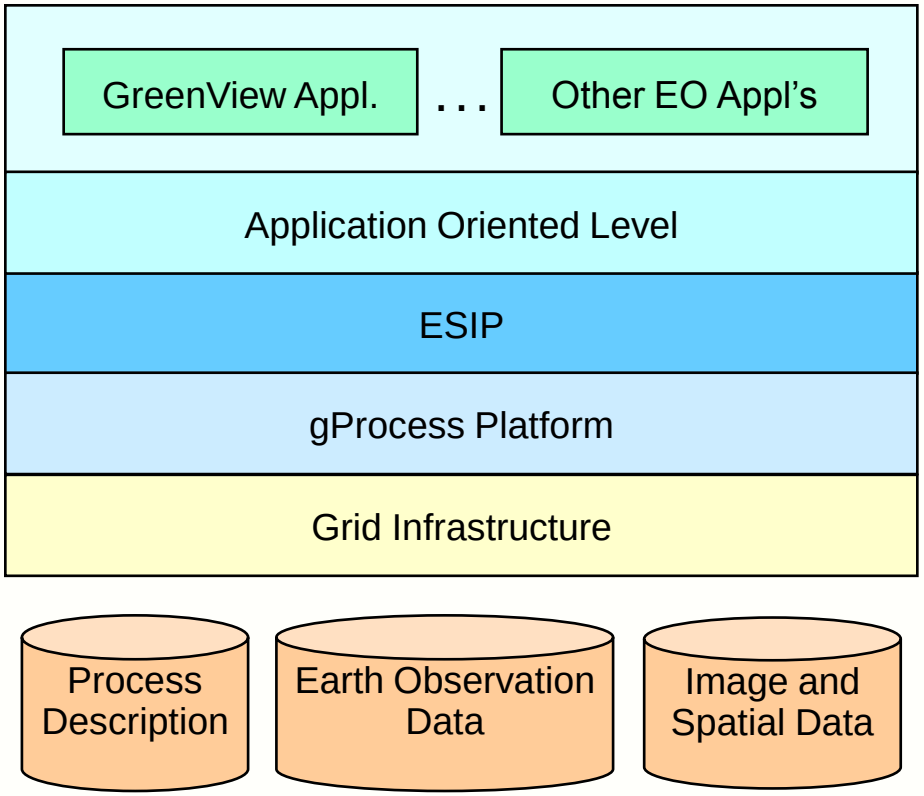
- **gProcess** and **ESIP** have been used to develop the **GreenView** application

- User Communities

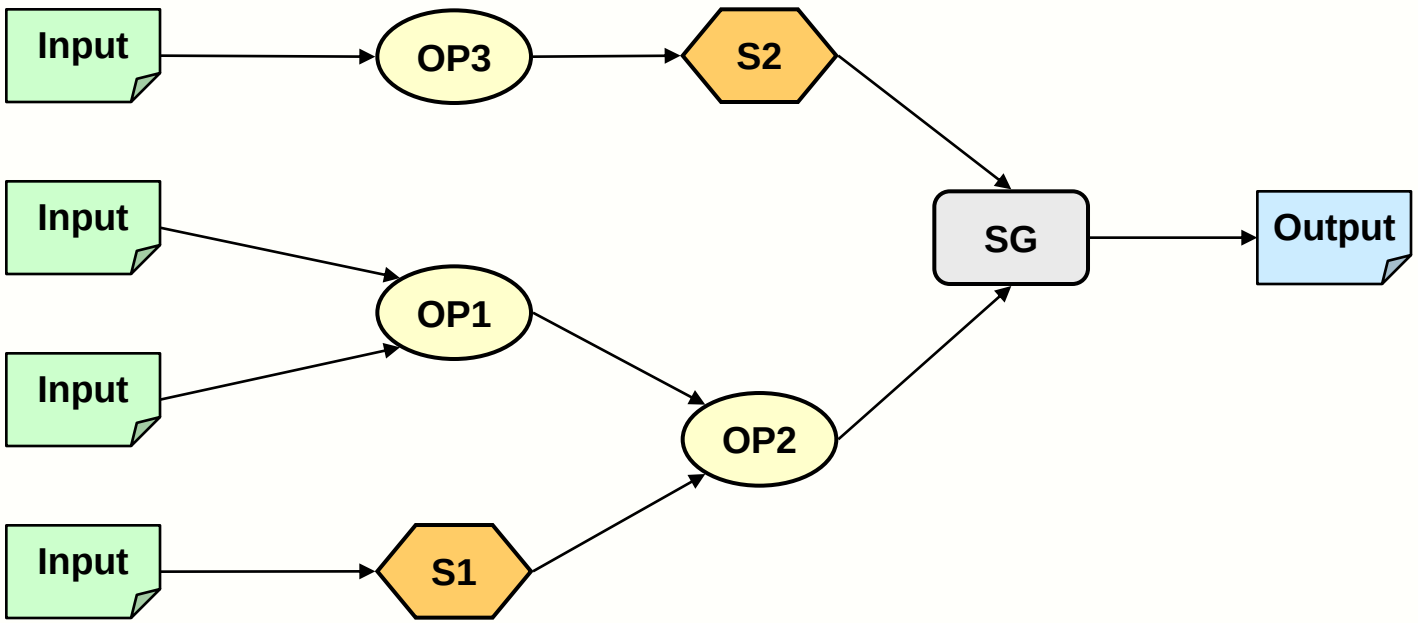
  The main beneficiaries of this VO are Government Organizations, Environment Agencies, Hydrological Institutes, and Research Groups involved in environment supervision and behavior prediction of natural phenomena, especially in vegetation related studies

gProcess and ESIP Functional Levels

- Grid Infrastructure
  - access to computational nodes, data, security
- gProcess Platform
  - set of services used for the management and the execution of iPDGs
- ESIP Platform
  - set of operators and services used in satellite image processing
- Earth Observation application
  - integrates all the features into a complex application



Hypergraphs – Process Description Graph



The hypergraph is a complex graph that combines operators (OP), services (S) and subgraphs (SG). The subgraph could be a simple or complex graph.

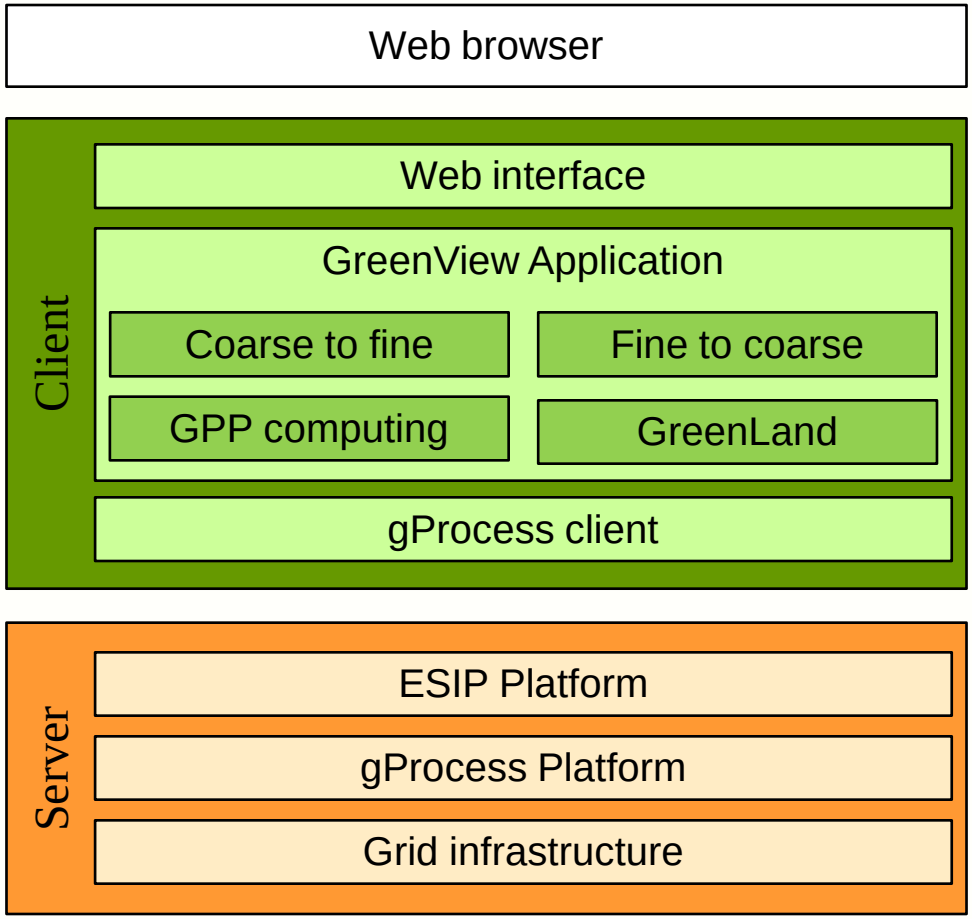
Inputs: Spectral bands in satellite images – MODIS, Landsat, QuickBird, etc
OP examples: Add, Subtract, Blur, Sharpen, EdgeDetection, HistogramEq, PseudoColoring, Erosion, etc.

GreenView Application

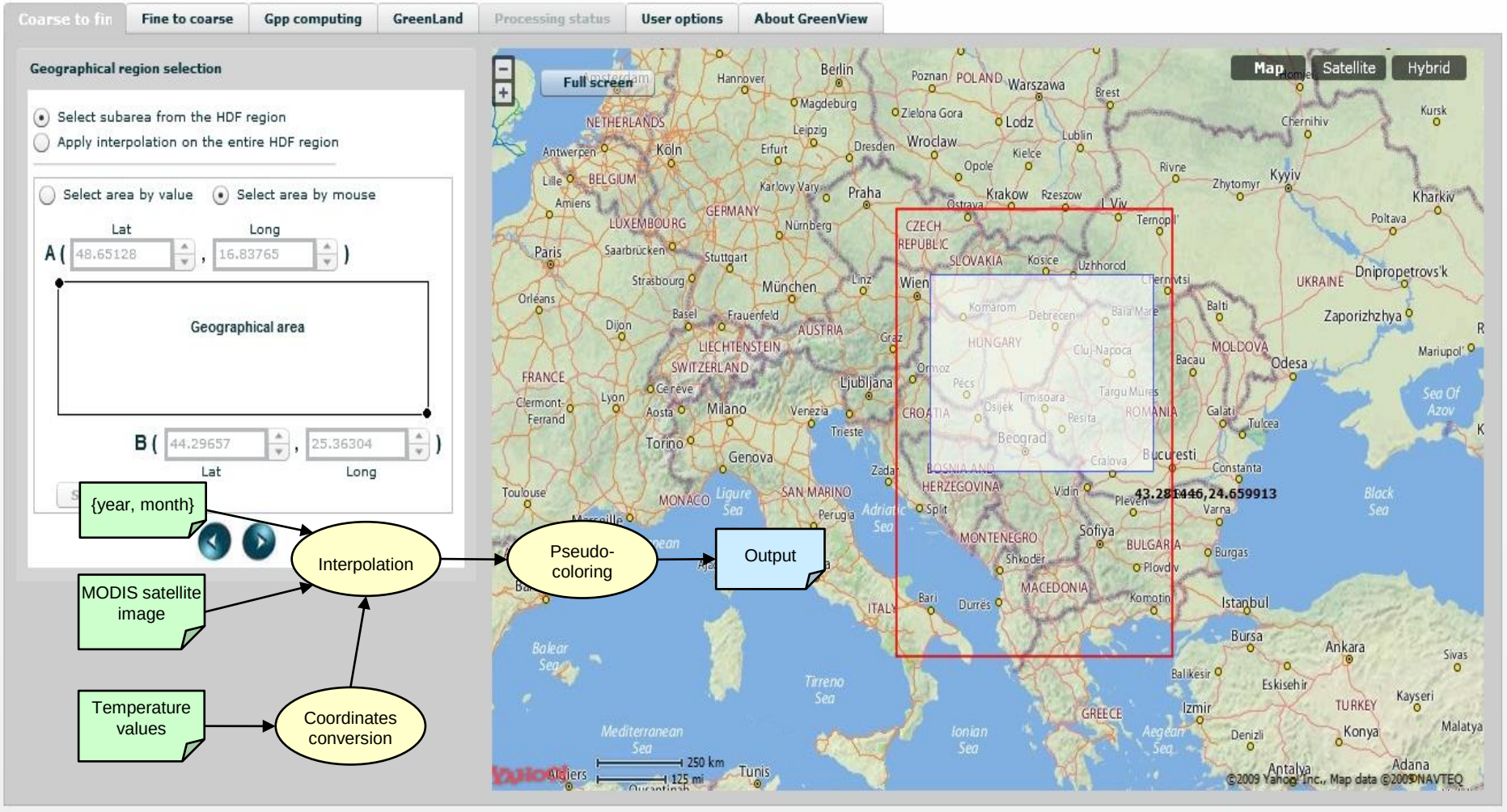
- **GreenView** is an environmental application used for predicting and monitoring the temperature over a specific geographical area. Classify the satellite images based on the computation of the vegetation indices. Actually it experiments the computation just for CEE regions. The functionality could be extended to other geographical areas.
- Demo is available at (sound on): http://cgis.utcluj.ro/movie/GreenView.wmv

- GreenView application is developing through the SEE-GRID-SCI Project (FP7), by the following partners:
  1. Technical University of Cluj-Napoca (UTCN), Politehnica University of Bucharest (NCIT), West University of Timisoara (UVT), and National Research Institute for Informatics (ICI)
  2. Eötvös Loránd University (ELU) from Budapest (Hungary)
  3. Research and Educational Networking Association of Moldova (RENAM)

GreenView Architecture



Coarse to Fine Interpolation – GUI Sample



GreenView - Results

Processing information

Processing ID: 895

Last refresh: 5 September 2009, 15:00:47 (refresh every 50 seconds)

Change refresh time: 50 seconds

description	Node name	Start server time	End server time	Status	Options
rezultat9.tif	33_FineToCoarse	2009-09-05 14:53:25	2009-09-05 15:03:04	DONE	
rezultat8.tif	30_FineToCoarse	2009-09-05 14:53:26	2009-09-05 15:03:14	DONE	
rezultat7.tif	27_FineToCoarse	2009-09-(			
rezultat6.tif	24_FineToCoarse	2009-09-(			
rezultat4.tif	18_FineToCoarse	2009-09-(			
rezultat5.tif	21_FineToCoarse	2009-09-(			
rezultat3.tif	15_FineToCoarse	2009-09-(			
rezultat2.tif	12_FineToCoarse	2009-09-(			
rezultat1.tif	9_FineToCoarse	2009-09-(			
rezultat10.tif	3_FineToCoarse	2009-09-(			
rezultat0.tif	6_FineToCoarse	2009-09-(			

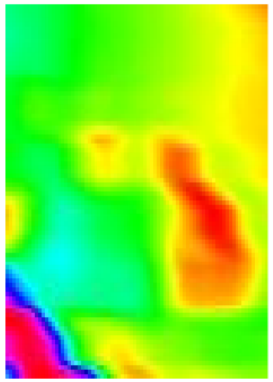
Result details for node: 27_FineToCoarse

Result file name: 6d9f073d-9353-4120-b364-56b6f51d9768/FineToCoarse_27_436.jpg

Processing start time: 2009-09-05 14:29:08

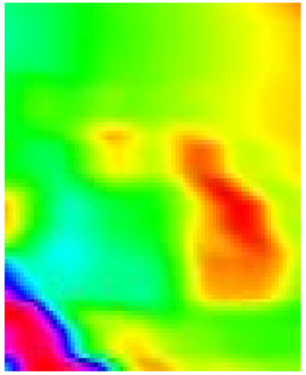
Processing end time: 2009-09-05 14:37:26

Image result for:



Slideshow: January 1961 - January 1961

Image title: 1961, January

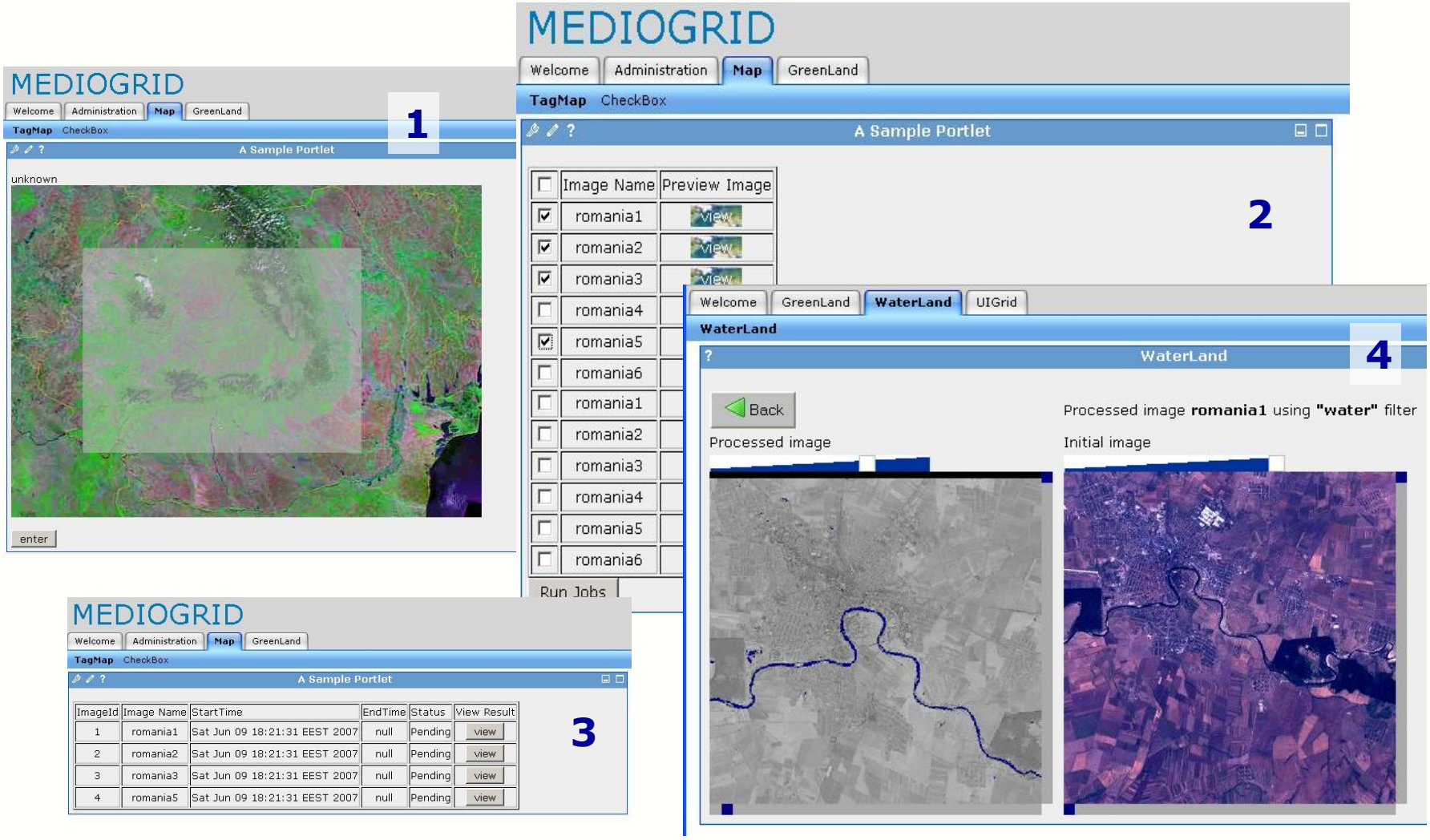


Node name: 21_FineToCoarse
File name: 040825e4-0073-41ff-91b1-b722bdf452bc/FineToCoarse_21_435.jpg
Start processing time: 2009-09-05 14:14:11
End processing time: 2009-09-05 14:27:33
Slideshow image position: 1 / 7

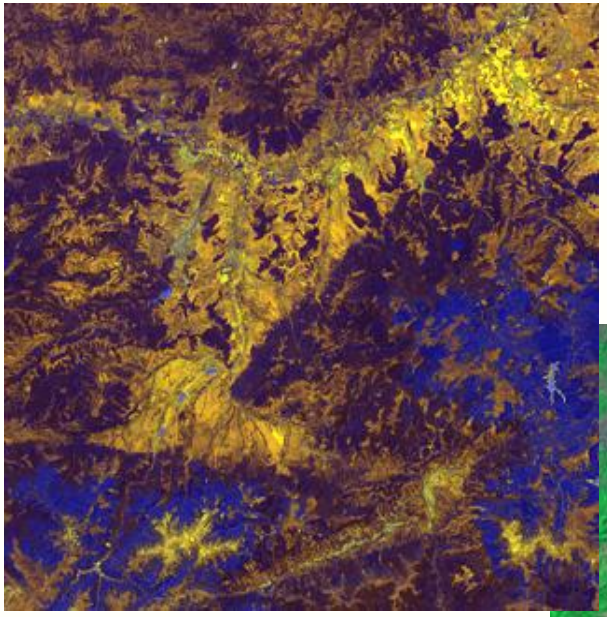
<< Prev | Pause | Next >>

Waterland Application

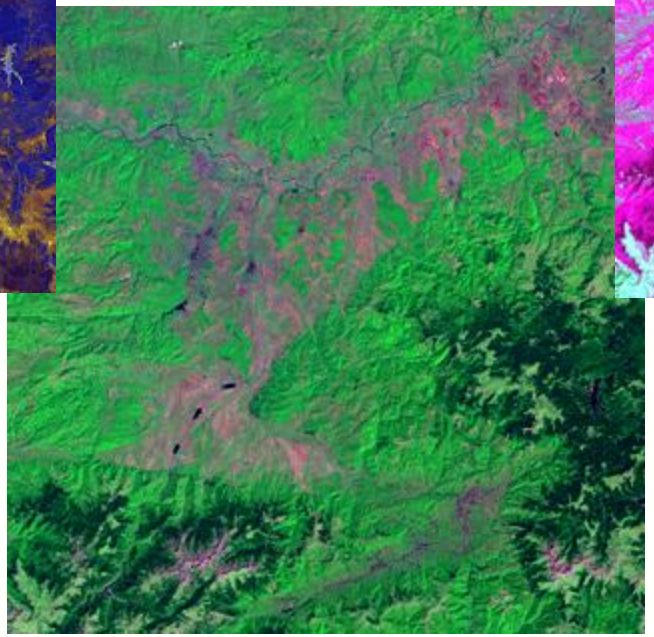
On-line available Web application: http://greenland.mediogrid.utcluj.ro



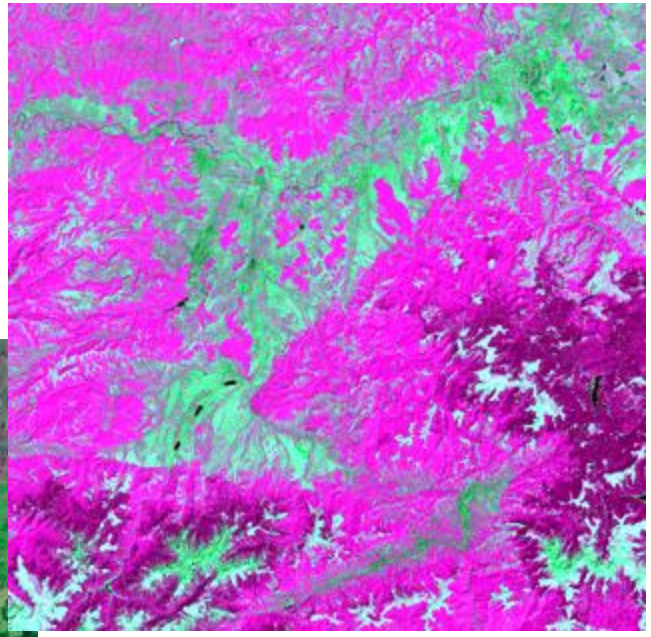
Minerals Application



Hydrothermally-altered areas.



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



Iron-oxides and hydroxyl-bearings minerals.

Research Project

- **eGLE (GiSHEO eLearning Environment)** application is developing through the GiSHEO Project.
- **GiSHEO** - On Demand Grid Services for Higher Education and Training in Earth Observation (http://gisheo.info.uvt.ro)
- Supported by ESA PECS Program (http://pecs.esa.int/) for the period of 2008-2010
- Demo available at (sound on): http://cgis.utcluj.ro/movie/eGLE.wmv

Research team (Romania):

1. West University of Timisoara (UVT)
2. Technical University of Cluj-Napoca (UTCN)
3. Romanian Space Agency (ROSA)
4. National Institute for Space Research (INCAS)

General Objectives in GiSHEO and eGLE

CGIS Computer Graphics and Interactive Systems

- Study the requirements and specifications for distance learning in Earth Observation training

  User requirements (i.e. professor, students), eLearning environment functional specifications, usability requirements, lesson structure, user interaction techniques.

- Tools development over GRID Technology to enable the creation and the execution of lessons for Earth Observation

  Create specialized tools that take advantage of GRID capabilities in a transparent manner for the user (student or teacher) in order to allow the processing of massive data.

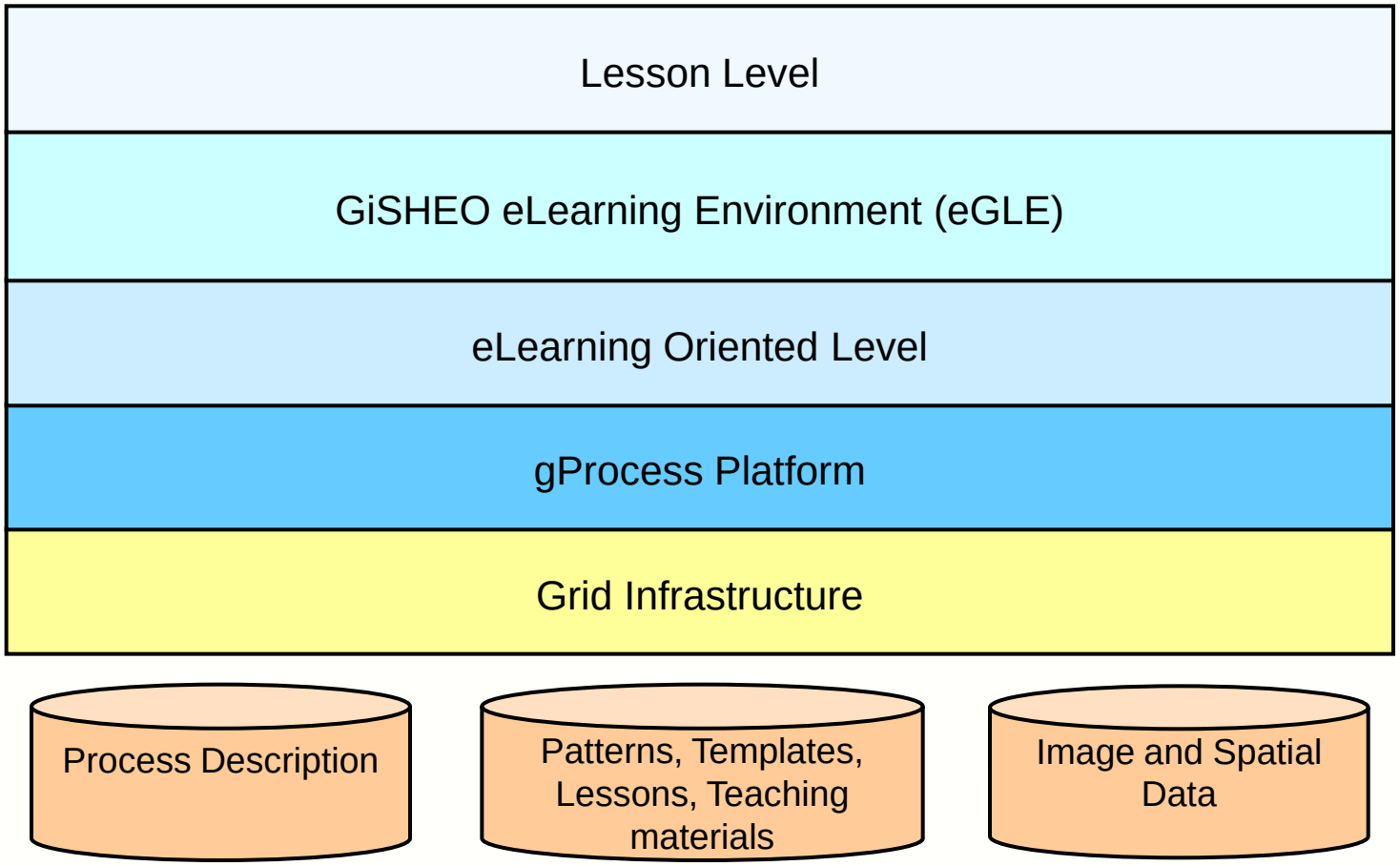
- Creation of lessons templates in order to allow non-technical teachers to create lessons for Earth Observation

  Create templates that allow teachers specialized in Earth Observation, but with non-technical studies, to develop new lessons by using GRID advantages and large amounts of data (satellite images).

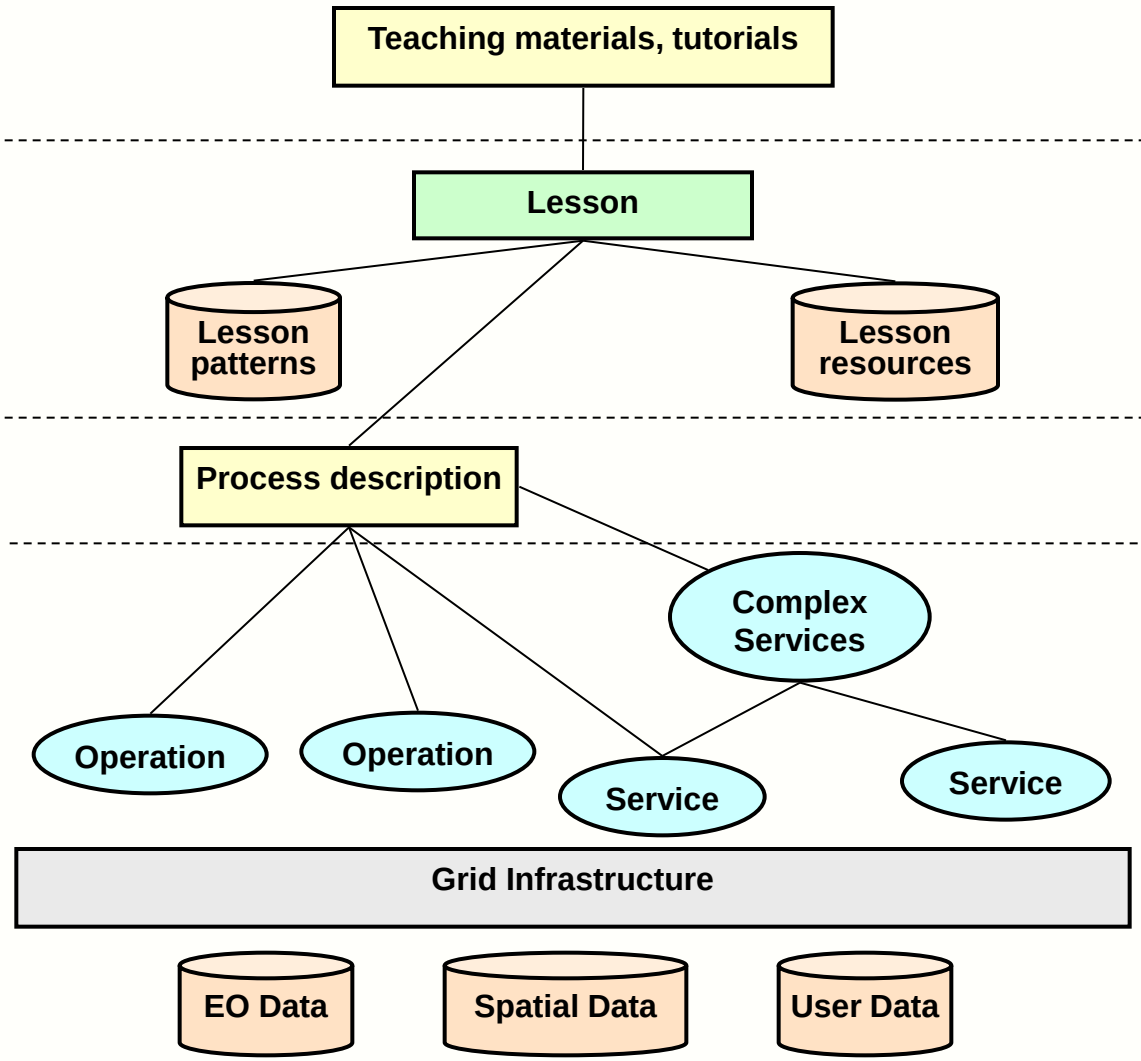
- Use Earth Observation data and services provided by GENESI-DR.

  Explore and experiment data availability and accessibility to GENESI-DR from remote Grid applications in terms of: accessing policies, types, formats, services, data replication, transfer performance, granularity, consistency, and efficiency

Functional Levels in eGLE Architecture



eGLE - Data and Process Flow



Teaching materials of various topics and subjects.

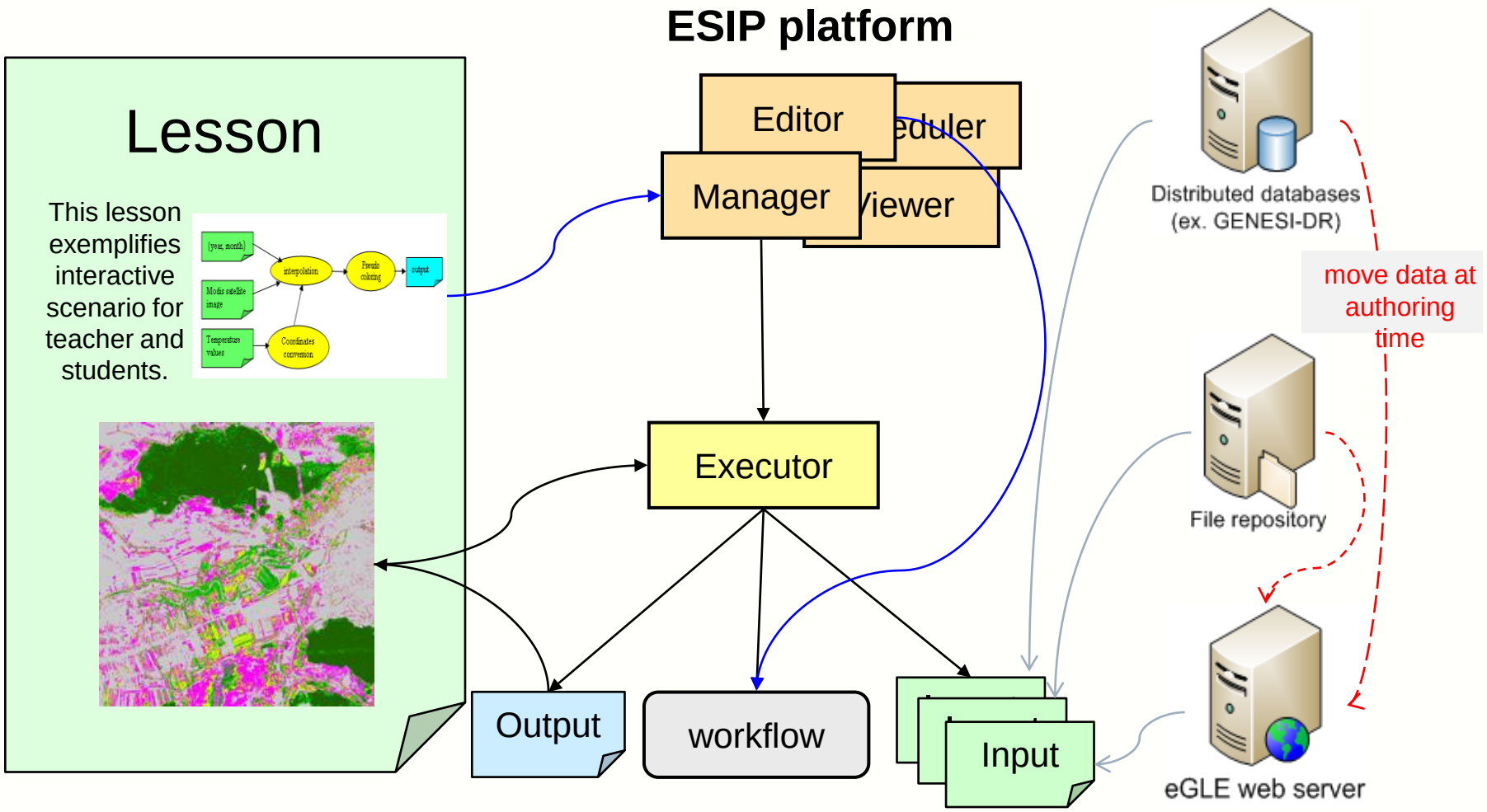
Lesson description, execution, and management.

Workflow based process description.

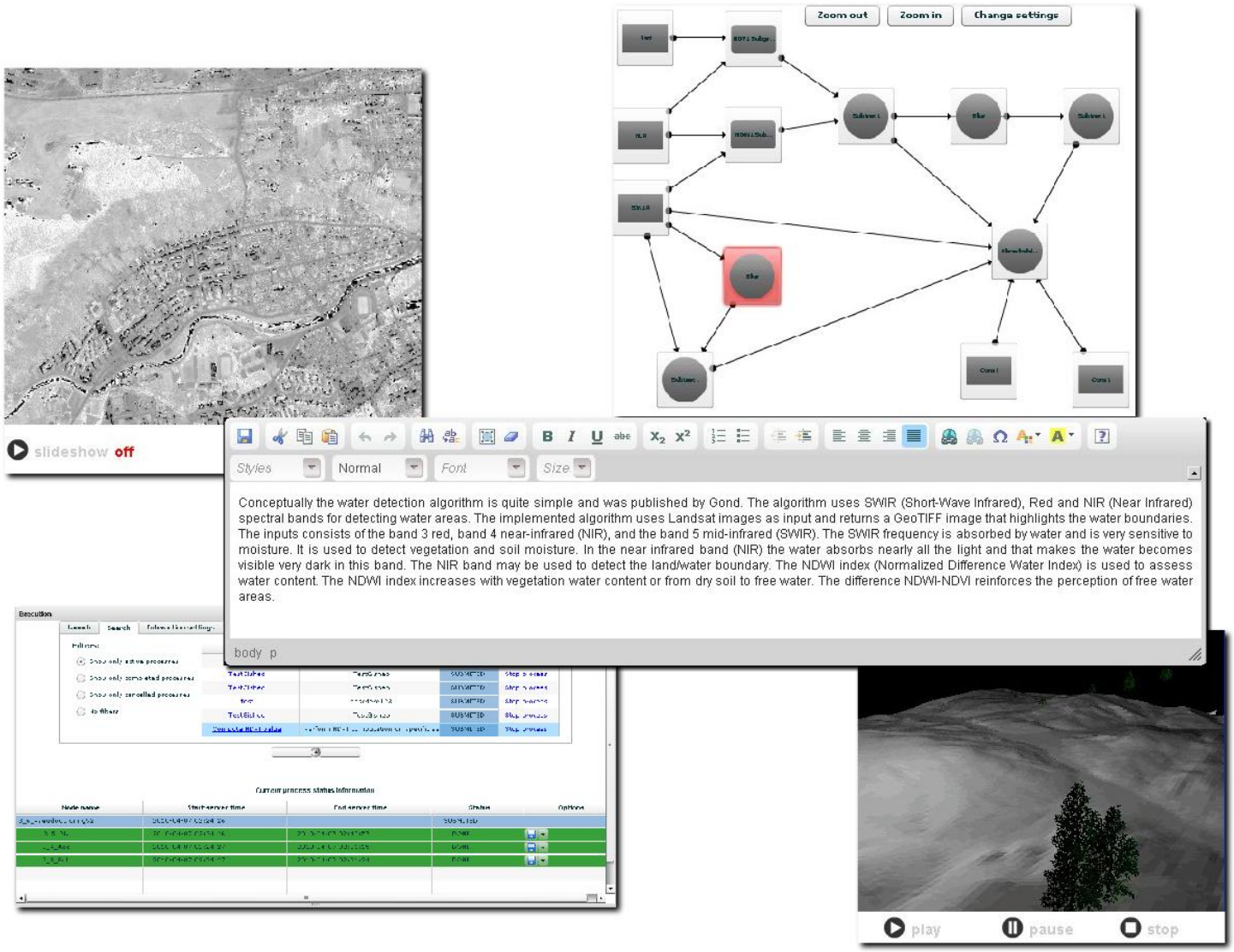
Service description, search, discovery and composition.

Services, operations from GiSHEO, GENESI-DR, other ESA projects.

Grid Based Execution of Env. Scenarios

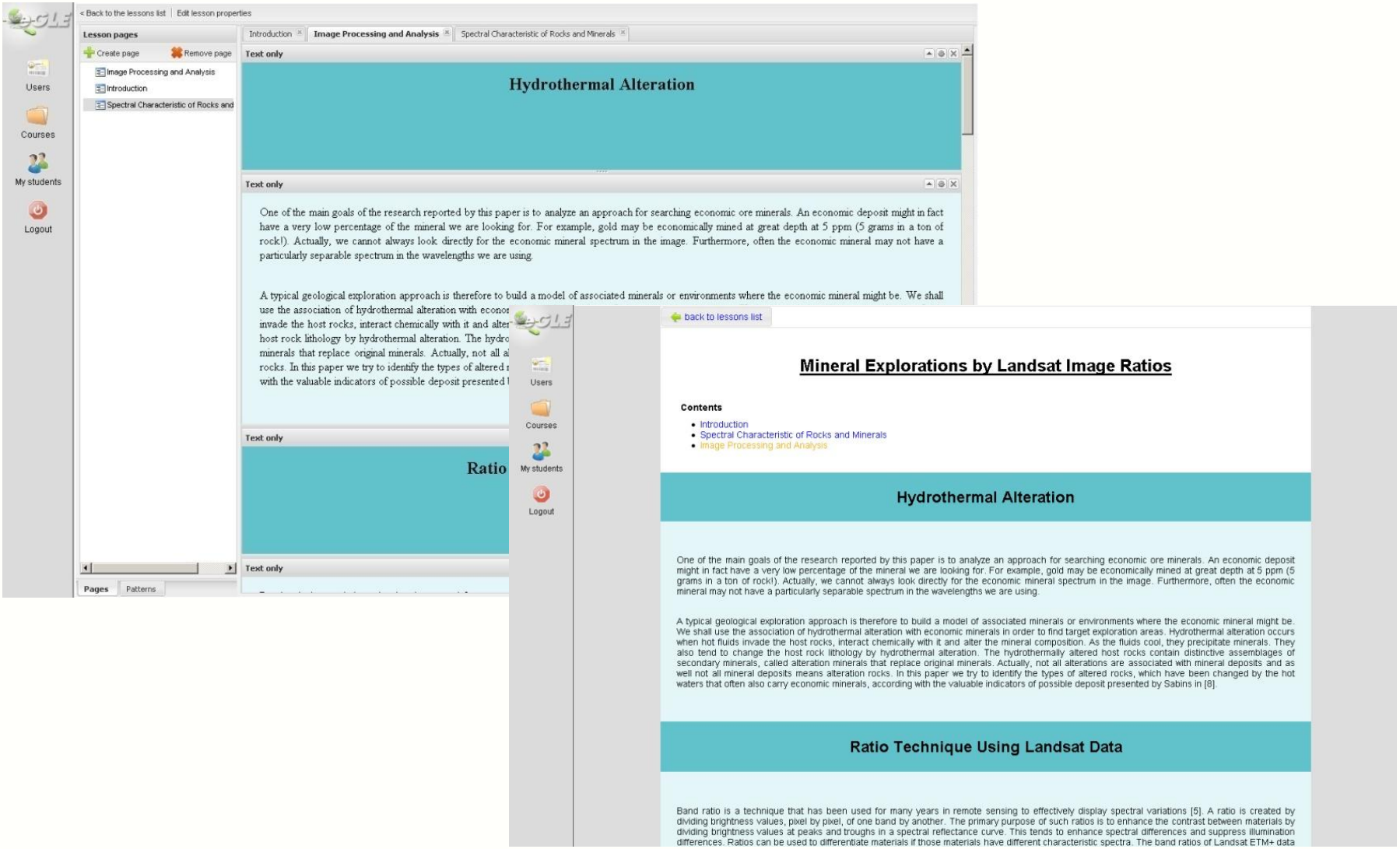


eGLE Tools



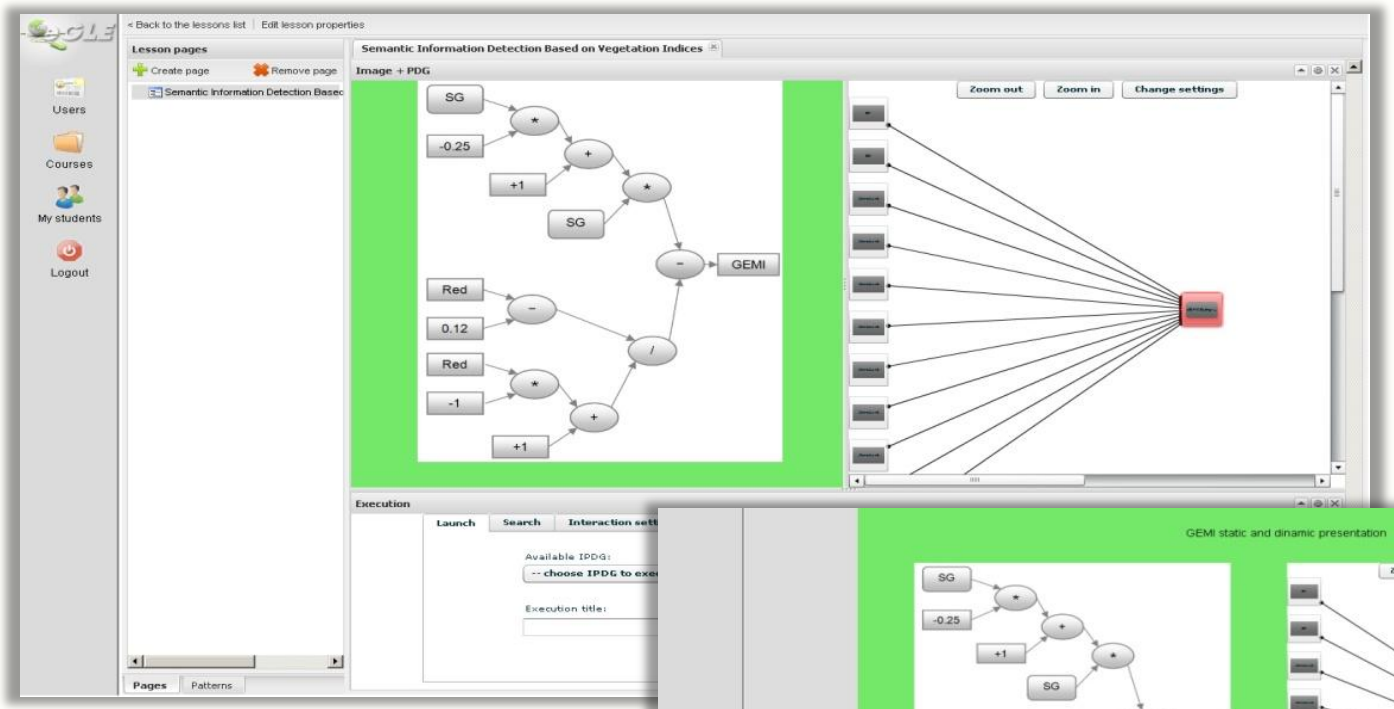
42

Lesson Samples



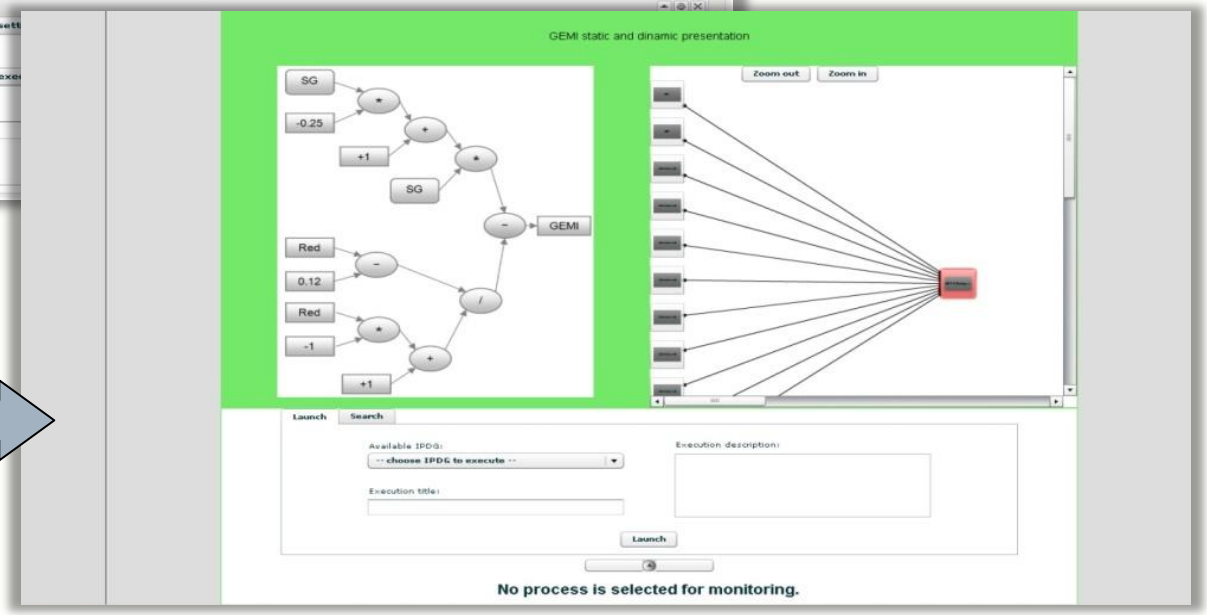
43

Lesson Samples



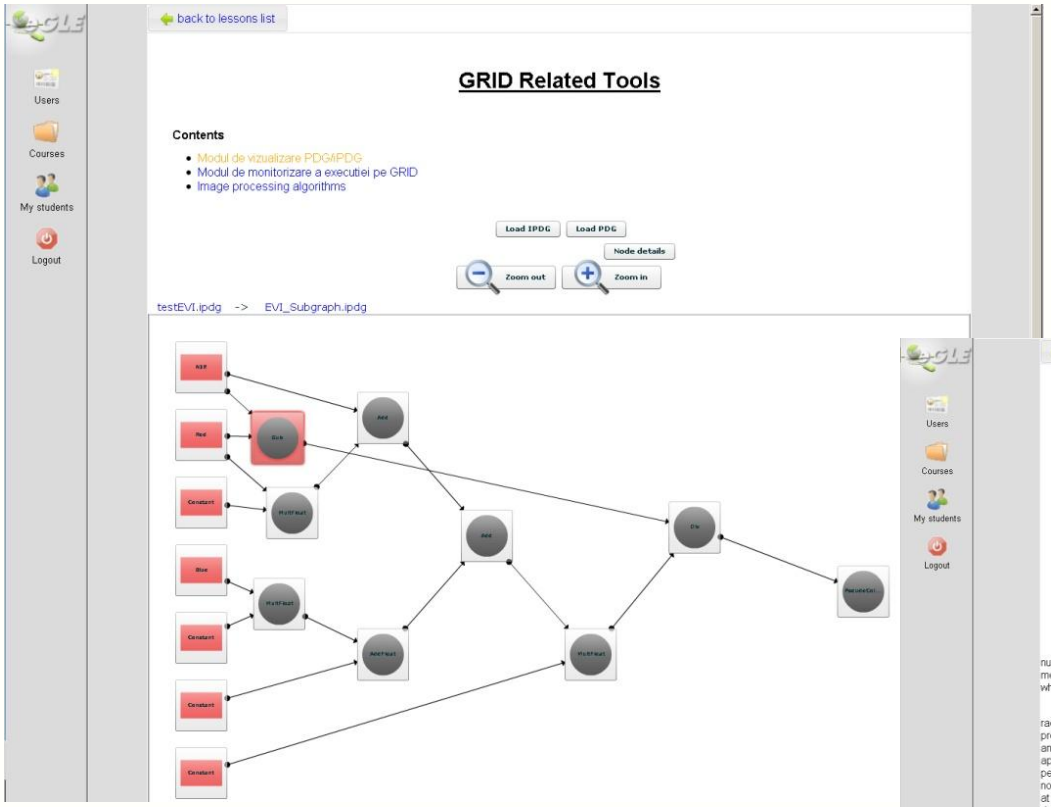
Authoring (WYSIWYG editor)

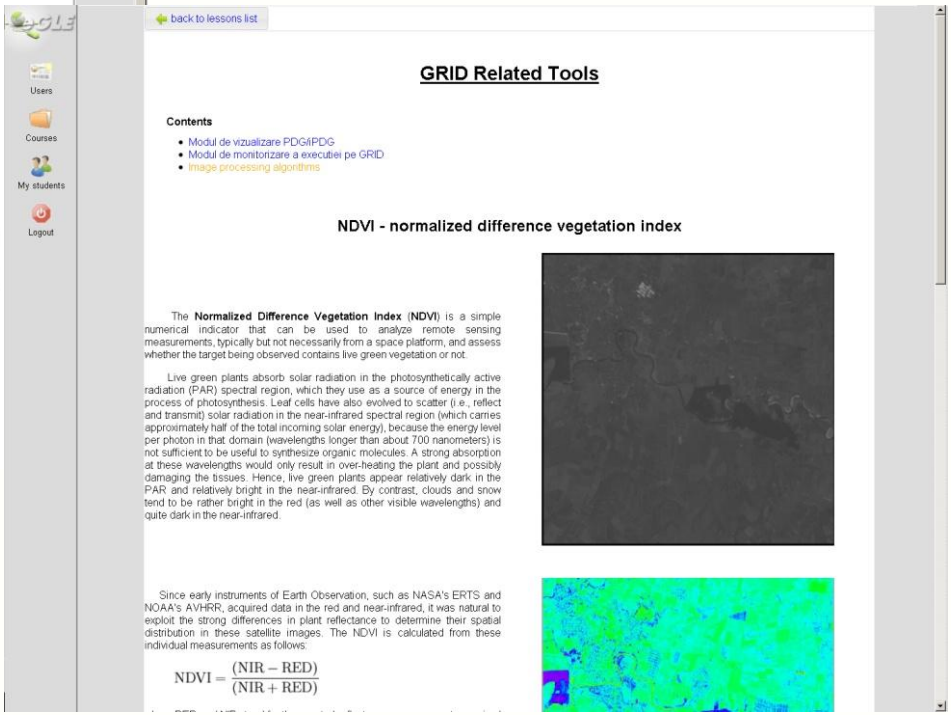
Runtime



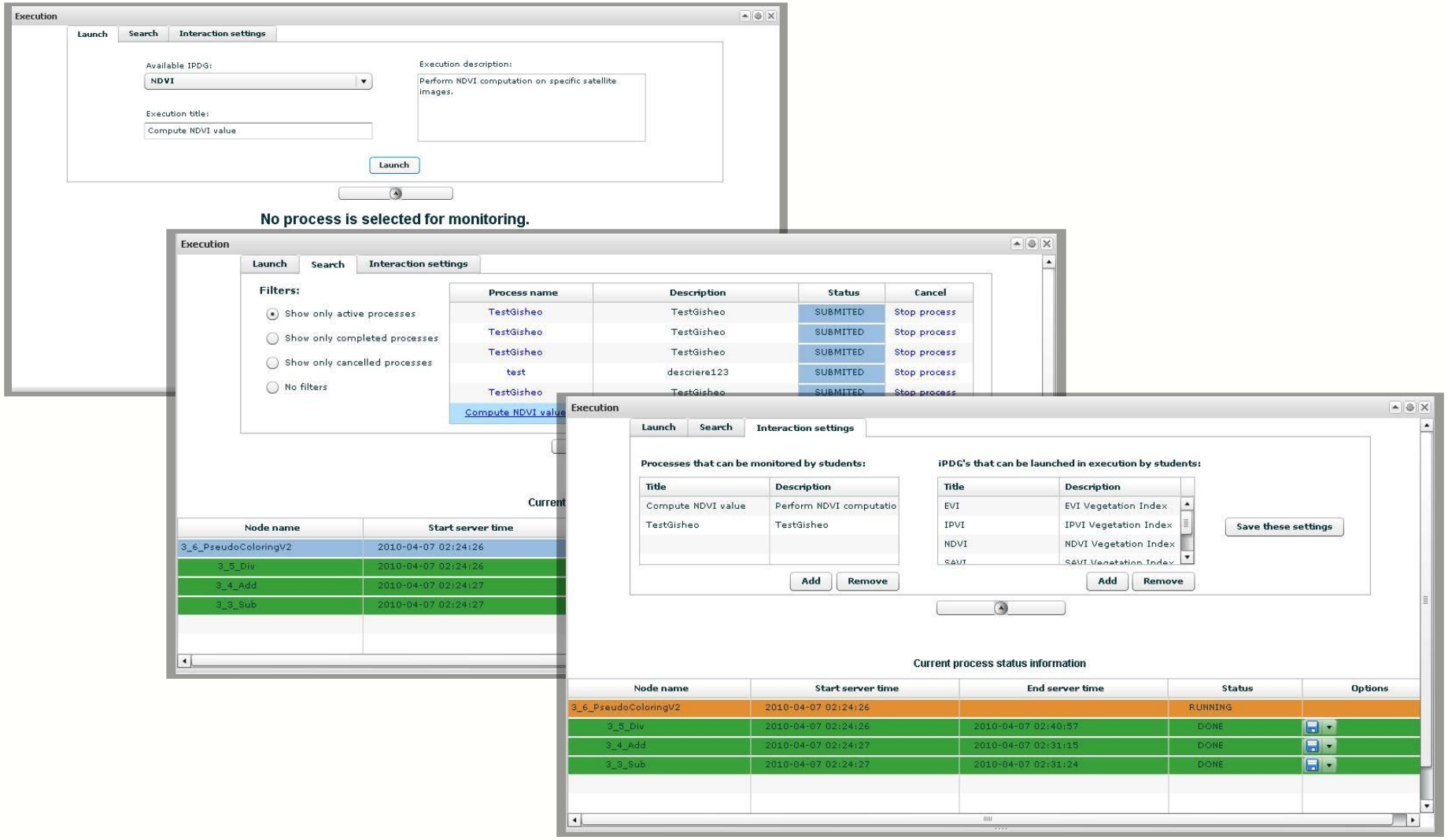
44

Lesson Samples – GRID Oriented Tools





Lesson Execution Monitoring

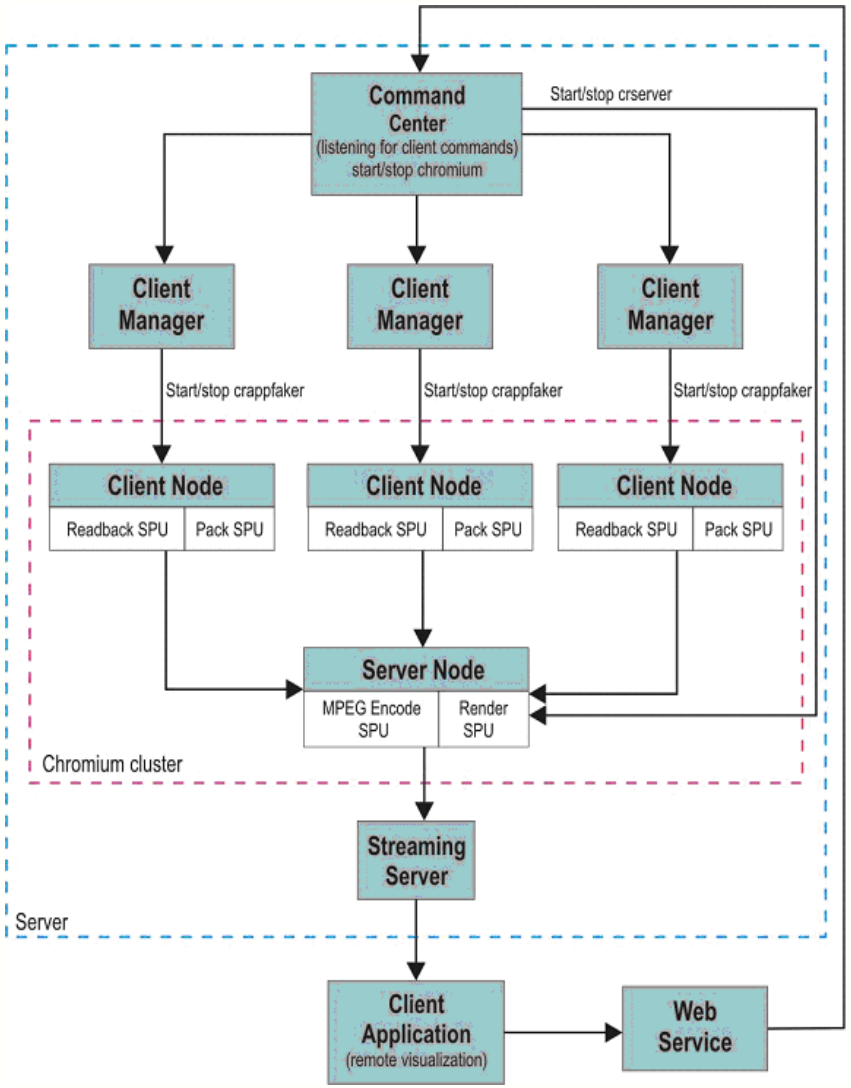


46

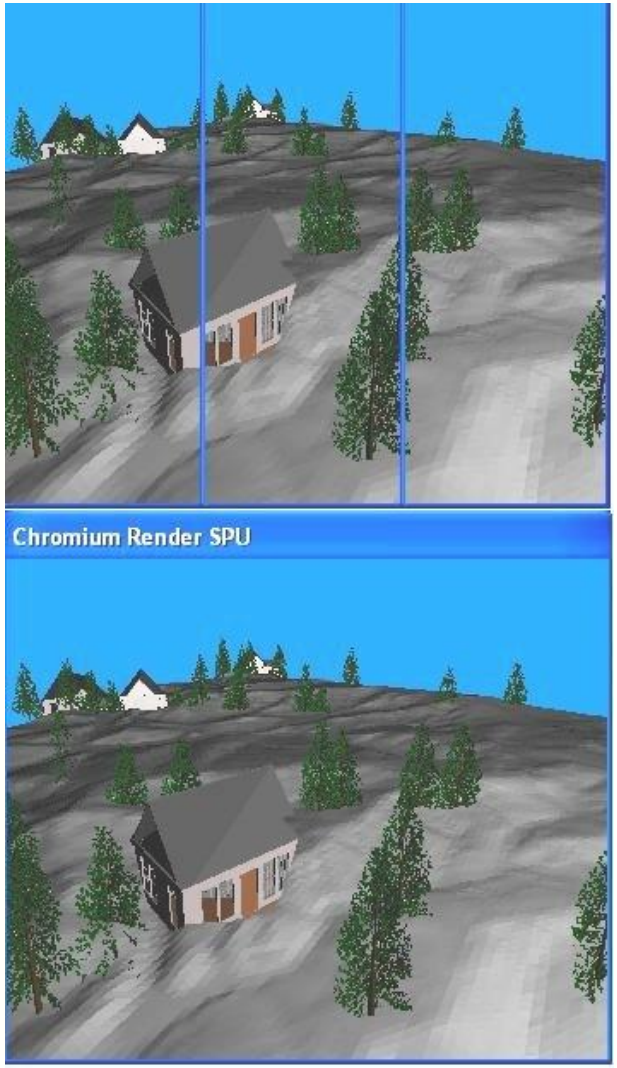
Virtual Geographical Space

- Develop a strong, intuitive language for generating visualization scenarios
- Enable parameterization of each created scenario
- Develop a desktop application that integrates the scenario language and allows the user to render in video or image file format
- Develop and test scene graph format, executable on the graphics cluster
- Test the system for execution and visualization of a 3D static or dynamic environment that is existent on graphics clusters

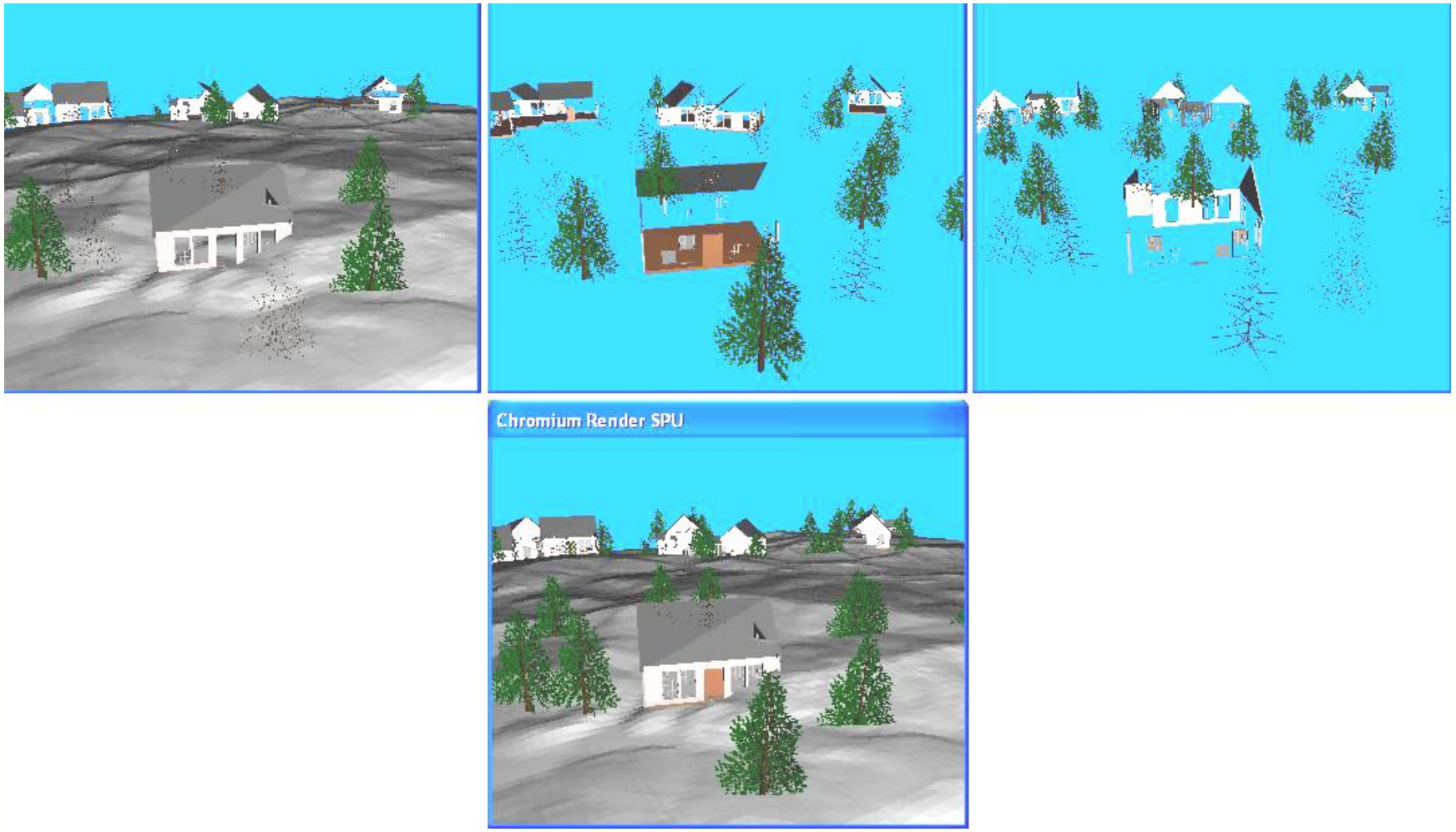
Remote Visualization Architecture



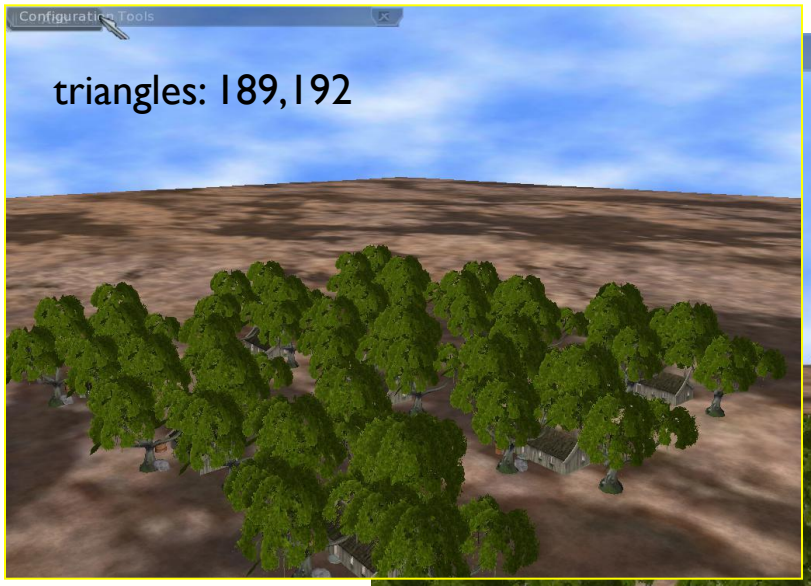
Sort-First Visualization Algorithm



Sort-Last Visualization Algorithm

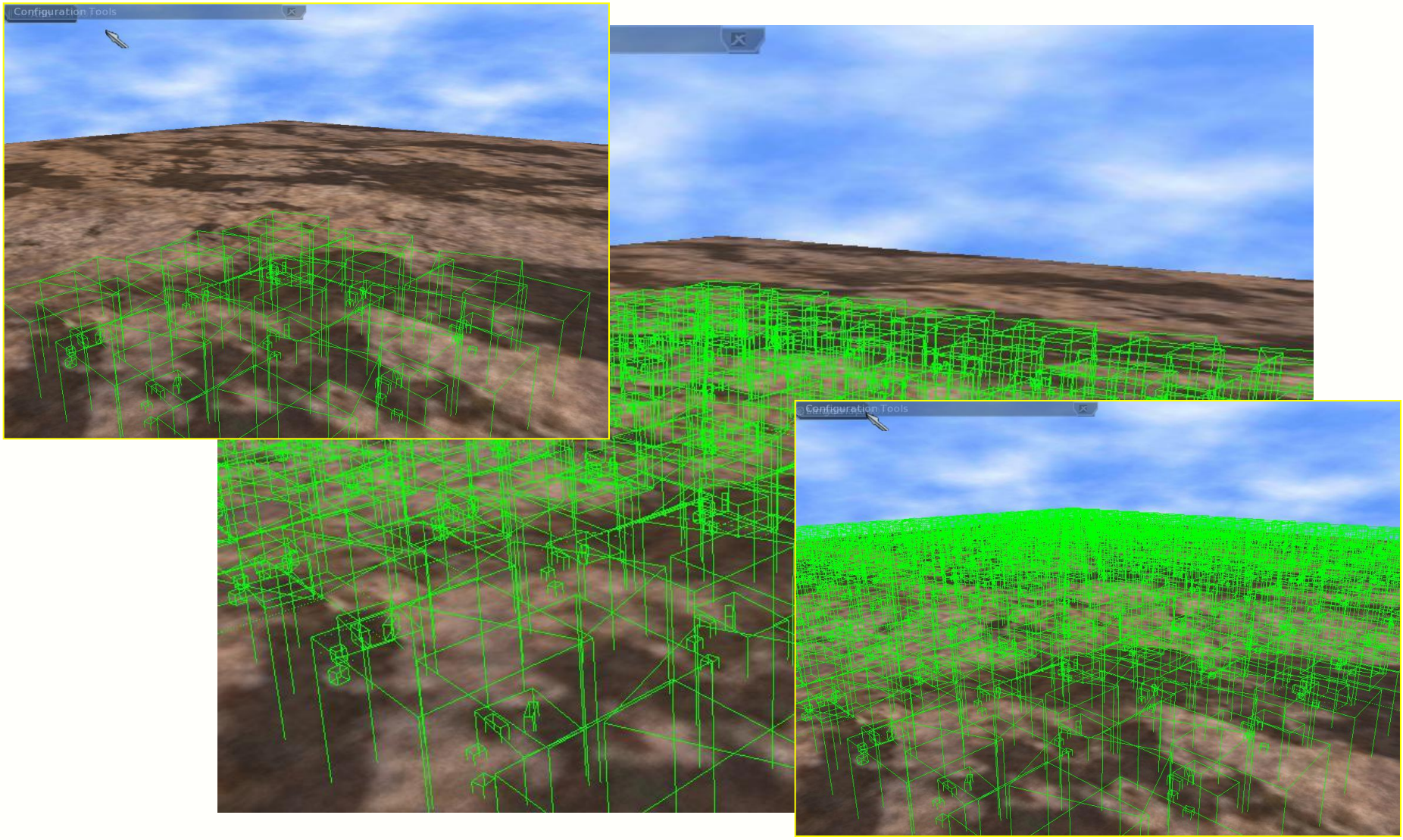


Scene Complexity



Scenario Description

CGIS
Computer Graphics
and Interactive Systems



Scenario Execution

- Camera control: 1st person perspective

- Camera control: 3rd person perspective

Thanks, Questions

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