



Grid based Hydrological Model Calibration and Execution by gSWAT Application



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enviroGRIDS Project

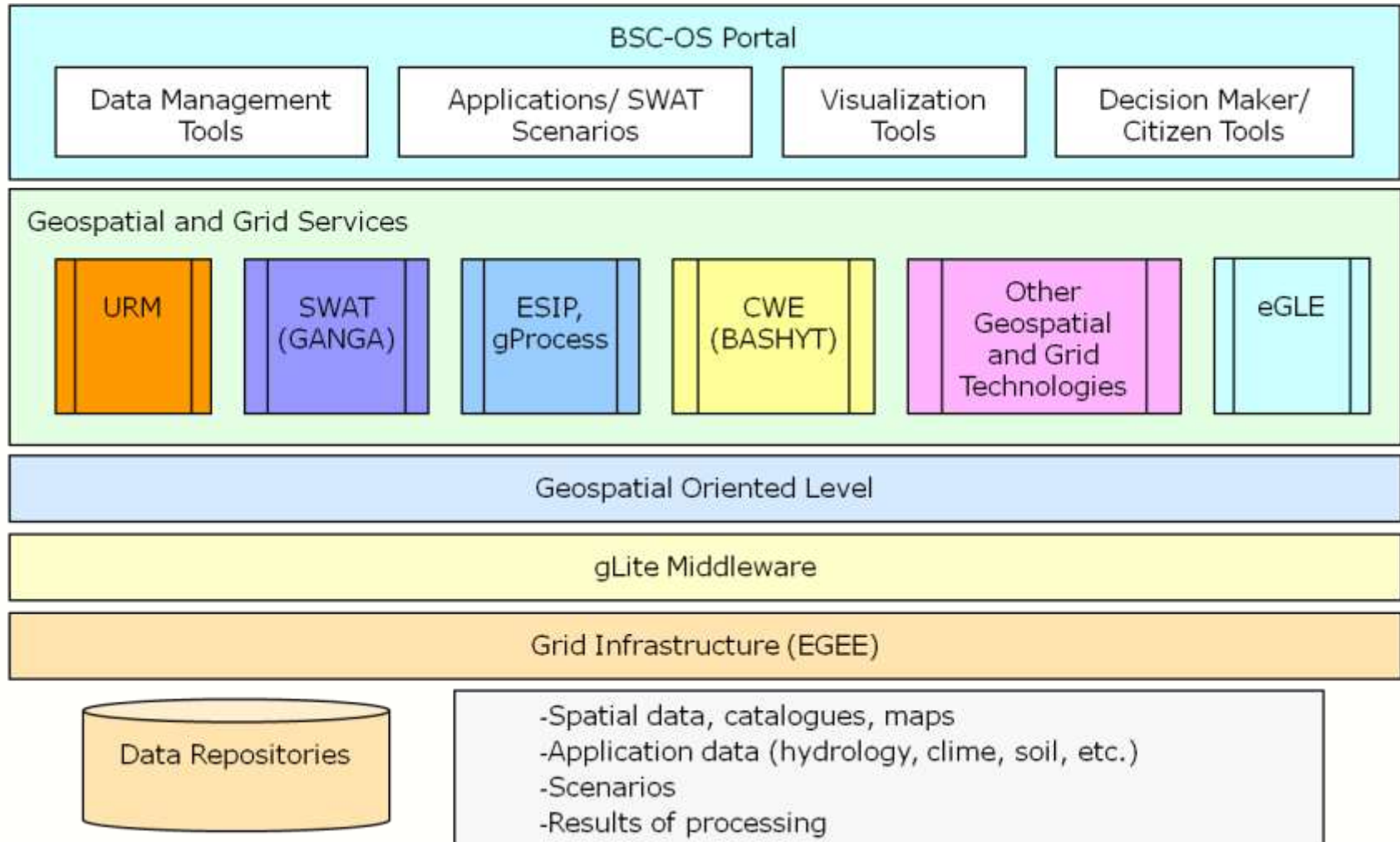


- **enviroGRIDS** - Gridifying the Black Sea catchment to support its sustainable development (<http://www.envirogrids.net>)
- Founded by the European Commission FP7 framework (Theme 6: environment), April 2009 – March 2013, 27 partners, 7.9 mil EUR.
- Coordinator
 - University of Geneva, Switzerland
- Objectives:
 - Develop a SDI (Spatial Data Infrastructure) targeting the Black Sea catchment region
 - Use new international standards to store, analyze, process, and visualize important information regarding this area
 - Perform distributed spatially-explicit simulations of environmental changes

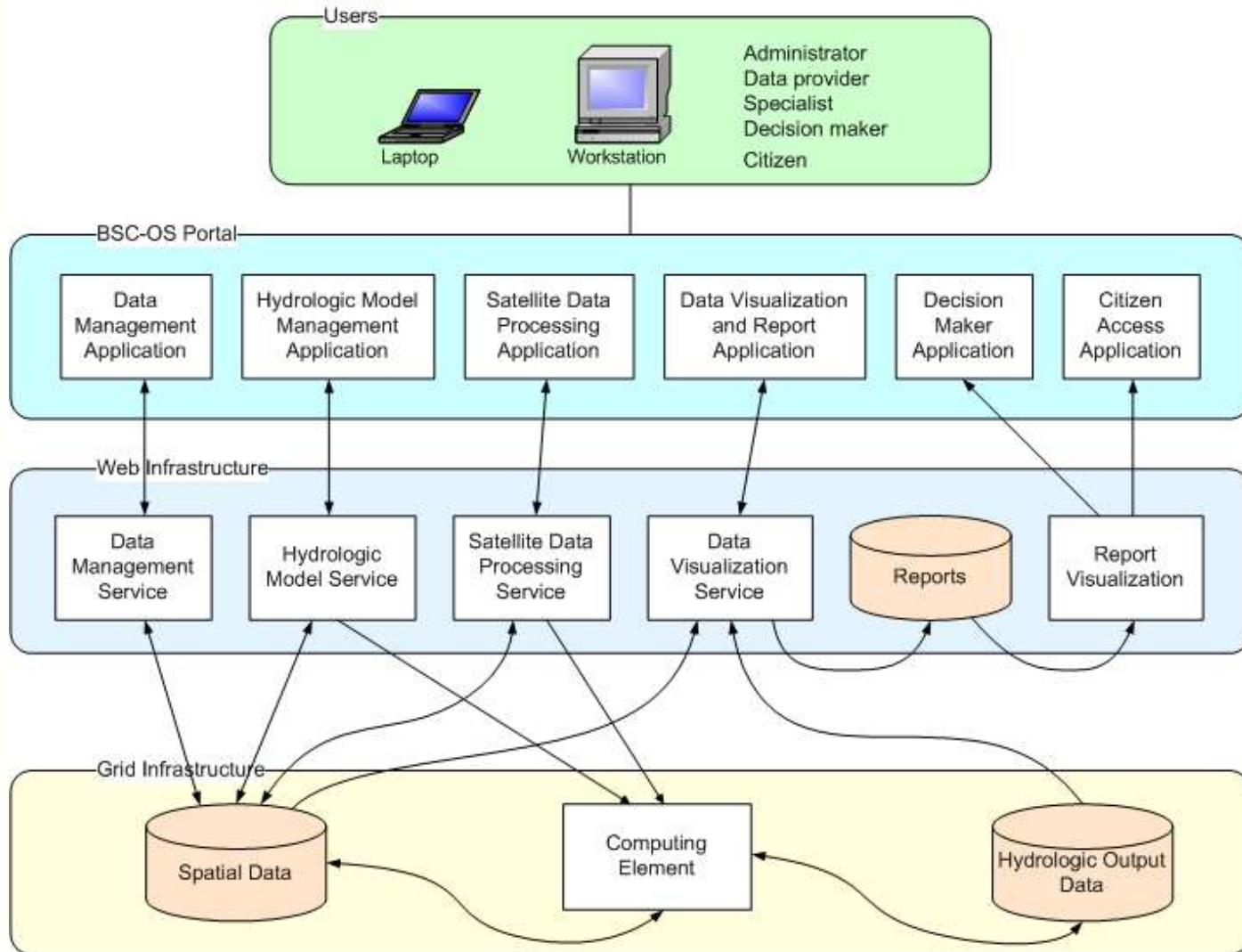


- Single way of the user to get into the enviroGRIDS system
- Exposes personalized tools for different category of users: data manager, earth science specialist, decision maker, citizen, and system administrator.
- Provide applications for:
 - data management
 - hydrologic models calibration and execution
 - 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

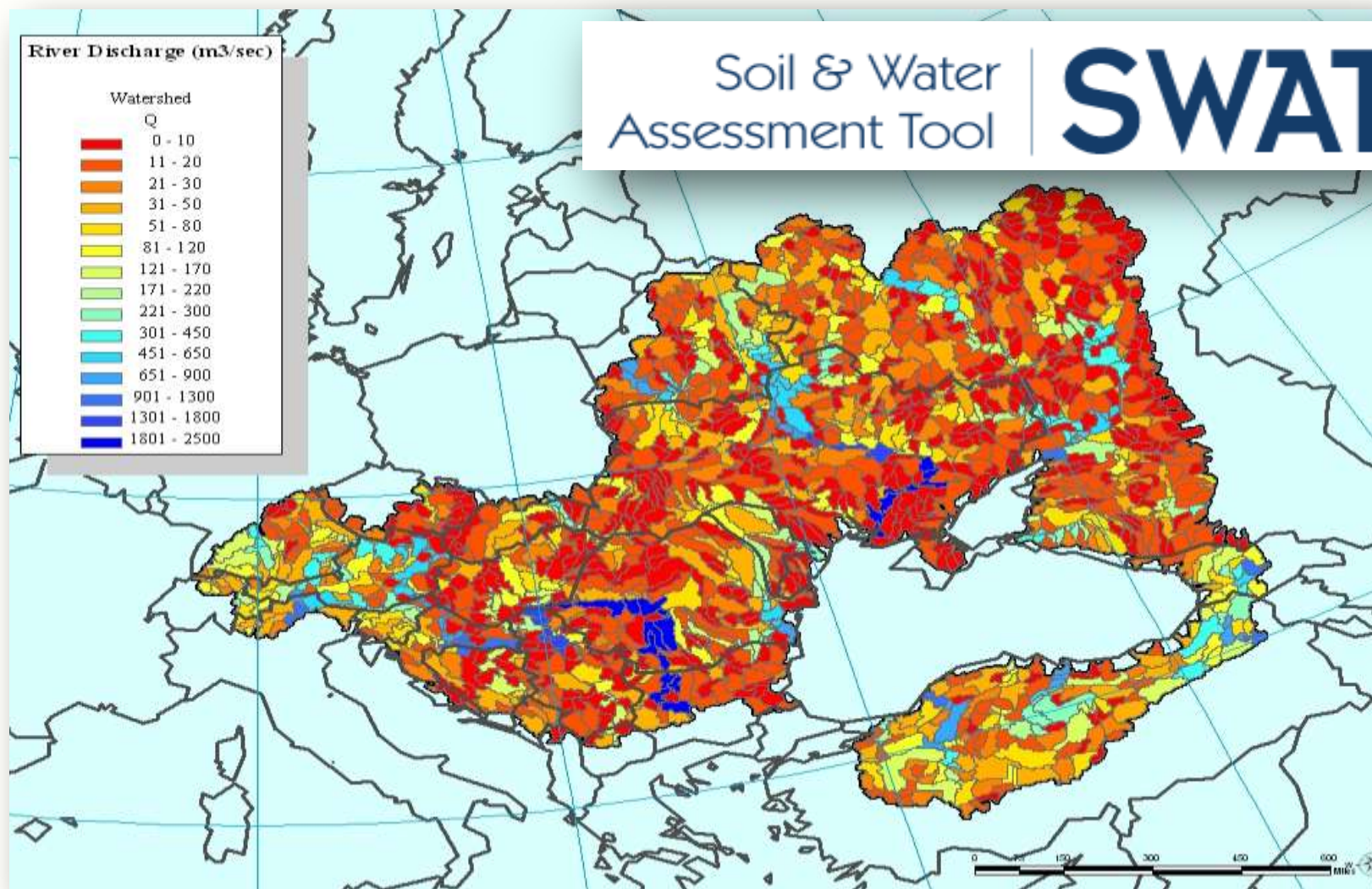
Portal Architecture



Data Flow Throughout the Portal



Black Sea Catchment Basin



Specific Objectives

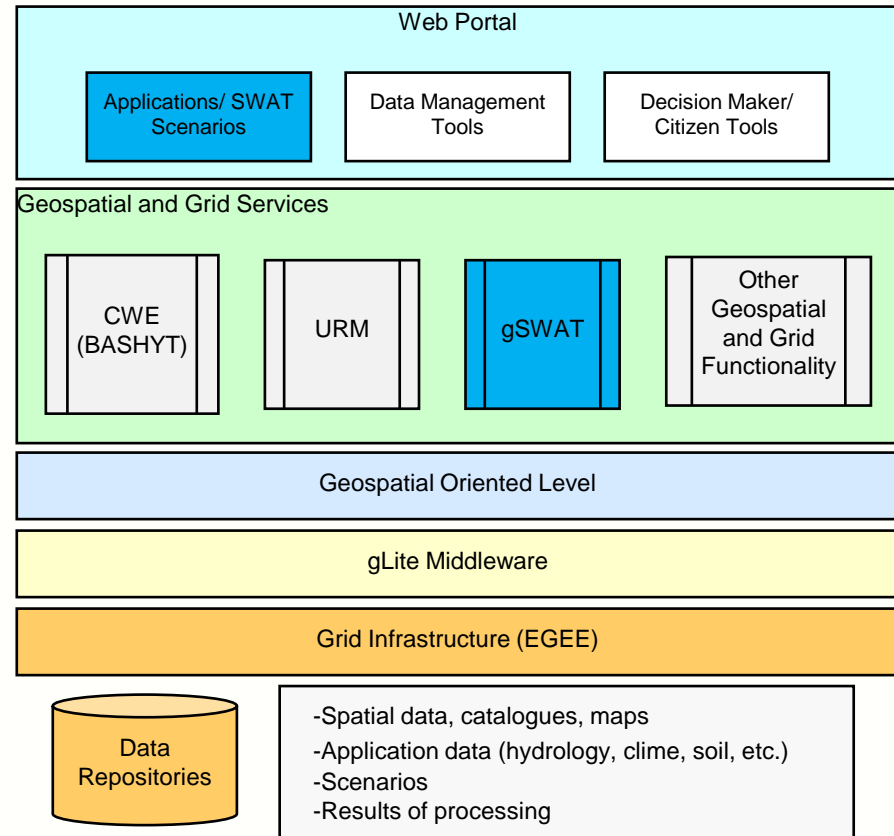


- Link, gather, store, manage and distribute key environmental data concerning the Black Sea Catchment Basin
- Large scale and high resolution distributed hydrological models
- Gridification of tools and applications
- Model and process huge spatial data over the Grid (e.g. hydrological models, satellite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

gSWAT Overview



- Main functionalities:
 - Calibration of the SWAT models (on GRID infrastructure)
 - Execution of scenarios based on a calibrated SWAT model (on GRID infrastructures)
- The calibration process uses the SUFI2 uncertainty analysis routine
- Web application



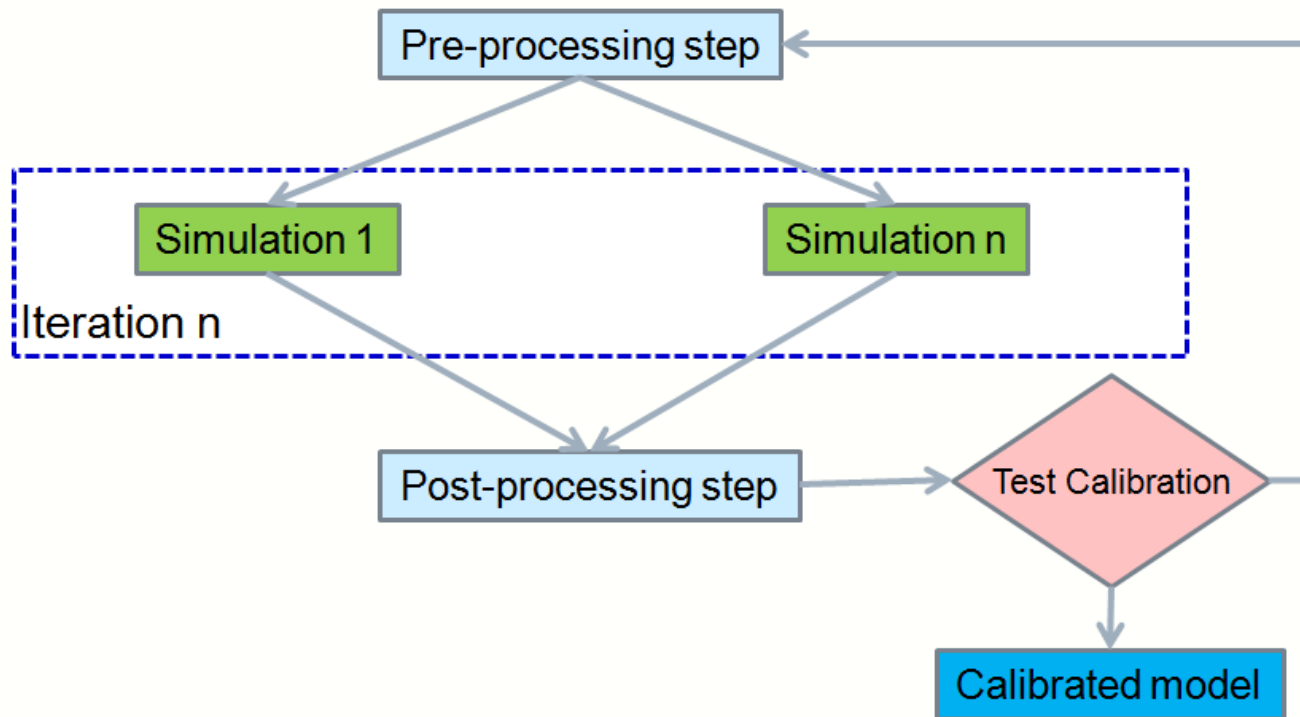
- Management of the SWAT calibration projects
 - Create new project
 - Upload SWAT model
 - Delete project
 - Modify calibration parameters
- Management of the execution of the calibration iterations
 - Start and monitor iterations
 - Save and delete completed iterations
- Output visualization
 - Graphical visualization

SWAT Calibration Process

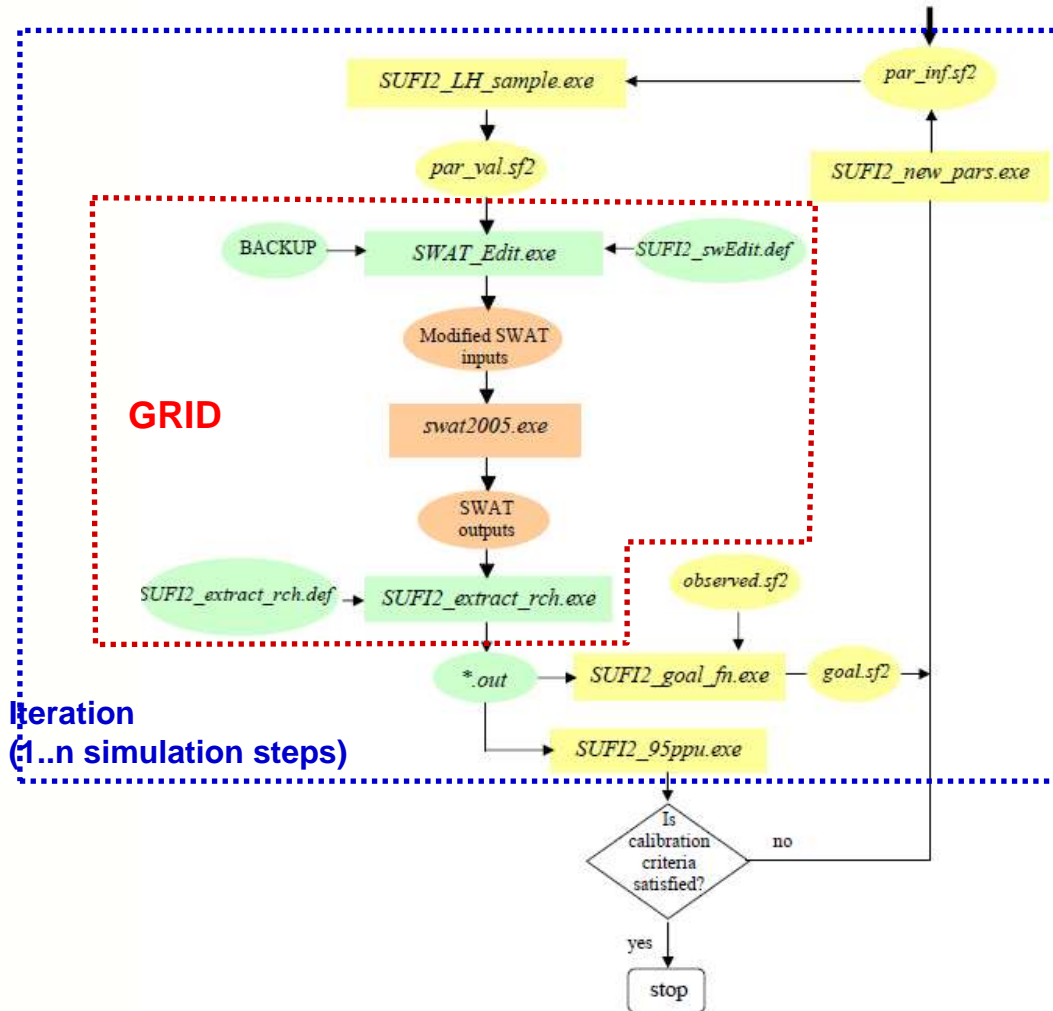


- **The calibration process** - execution of several iterations until the calibration criteria is satisfied.
- Each **iteration** process is composed of a number of simulations.
- Each **simulation** is independent on the other simulations.
- The user can choose between several objective functions.
- After performing an iteration the user can change the type of the objective function to see the effect of this objective function.

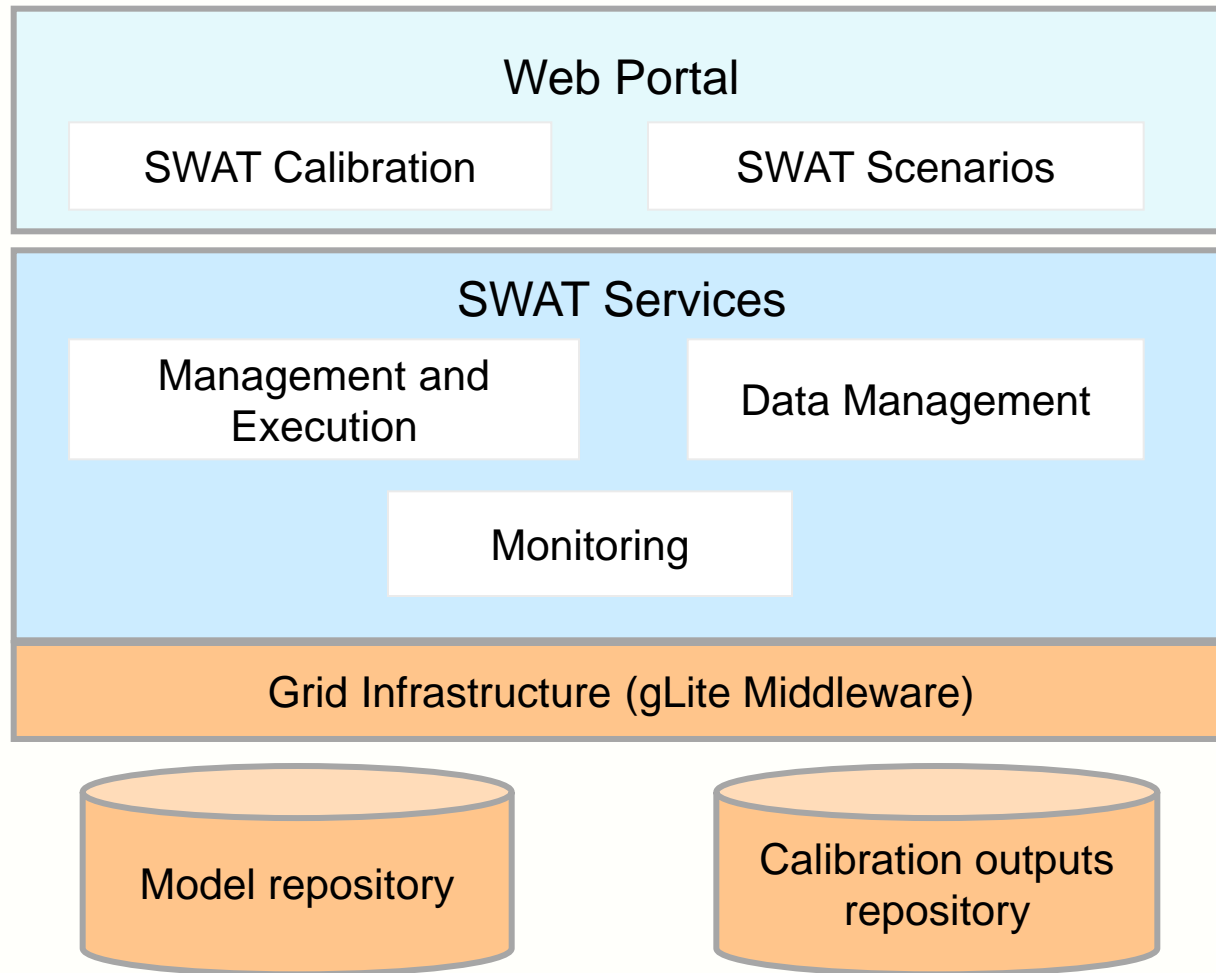
Processing steps



The calibration process



gSWAT Application - Architecture

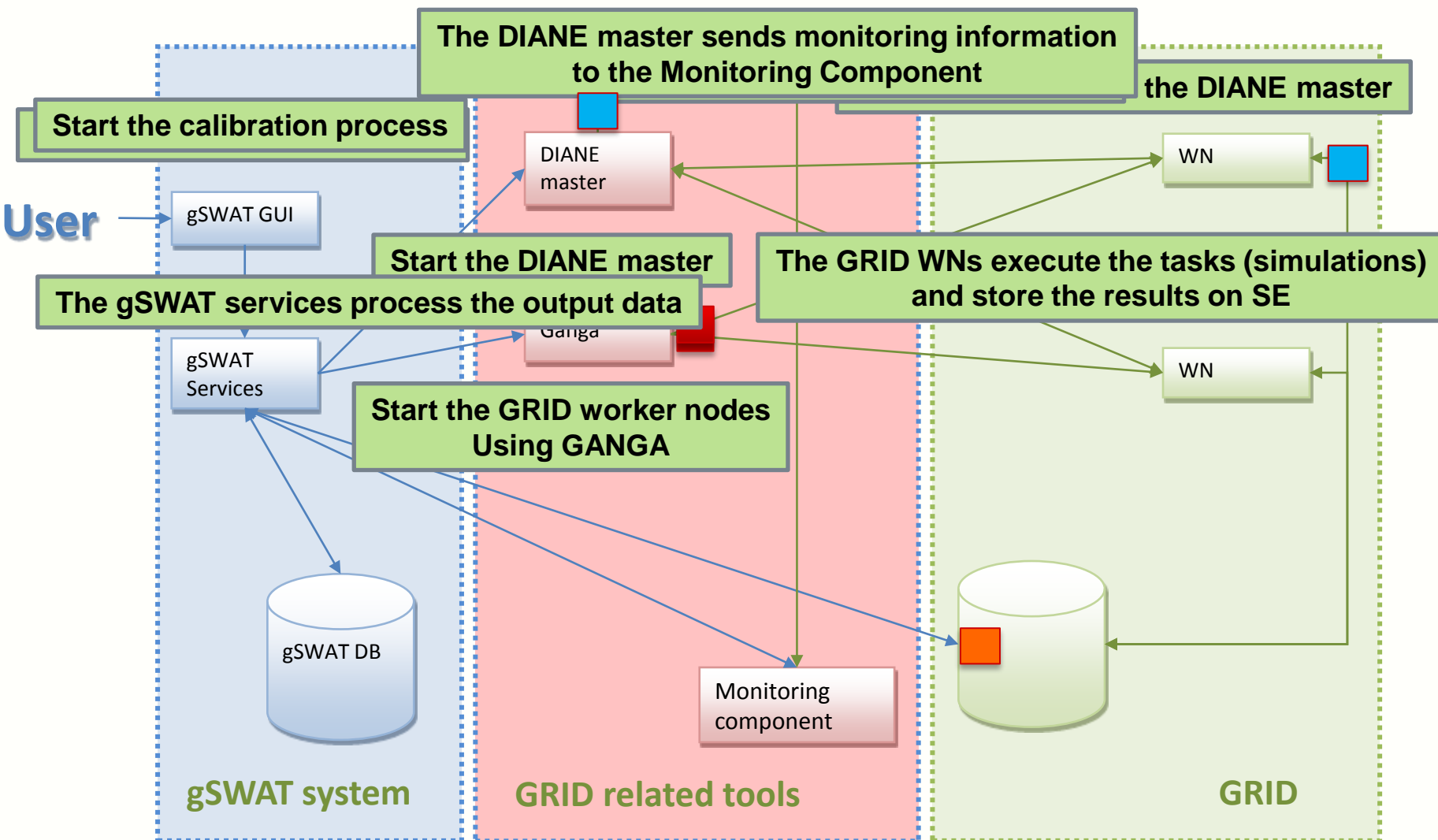


gSWAT Execution Flow



1. Create the job script
2. Create the DIANE script
3. Start the DIANE master
4. Start the Grid workers using GANGA
5. Monitor the execution of the tasks (simulations)
6. Download the output data

gSWAT Execution Flow




gSWAT User Interface




- Project list and detailed information on the selected project

Projects List

Project0
Created at: Sat Jan 29 20:21:57 GMT+0200 2011
Status: Uploading project 

Project1
Created at: Sat Jan 29 20:21:57 GMT+0200 2011
Status: Incomplete uploading

Project2
Created at: Sat Jan 29 20:21:57 GMT+0200 2011
Status: Loaded project

Project3
Created at: Sat Jan 29 20:21:57 GMT+0200 2011
Status: Running iteration 

Project4
Created at: Sat Jan 29 20:21:57 GMT+0200 2011
Status: Finished iteration

Name: Project4


Created at: Sat Jan 29 20:21:57 GMT+0200 2011

Executing since: Sat Jan 29 20:21:57 GMT+0200 2011 (13min ago)

Status: SWAT model calibration ended successfully

ArcSwat model: ArcSwat 2009

Description:

[Output results:](#) 

Create a new project



- Step 1: Define general project information

A screenshot of a software dialog box titled "Create a new project". It contains three input fields: "Project name:" with the text "Black Sea Catchment model", "Project description:" with the text "Calibrate the SWAT model that contains information about the Black Sea Catchment", and "TxtInOut created with:" with a dropdown menu showing "ArcSwat 2005". At the bottom are two buttons: "CREATE PROJECT" and "CANCEL".

Create a new project

Project name: Black Sea Catchment model

Project description: Calibrate the SWAT model that contains information about the Black Sea Catchment

TxtInOut created with: ArcSwat 2005

CREATE PROJECT CANCEL

- Step 2: Select the SWAT model to be uploaded

A screenshot of a software dialog box titled "Upload project files". It contains one input field: "TxtInOut archive location:" with the placeholder text "Complete path to archive (zip, rar, tar.gz)" and a "Browse" button. At the bottom are two buttons: "UPLOAD" and "CANCEL".

Upload project files

TxtInOut archive location: Complete path to archive (zip, rar, tar.gz) Browse

UPLOAD CANCEL

Modify SUFI2 calibration parameters



enviroGRIDS test victor 1 - gSWAT Calibration

Start calibration Save iteration Delete iteration Save Save all Close tabs Project logs Close project

Project status: Finished iteration

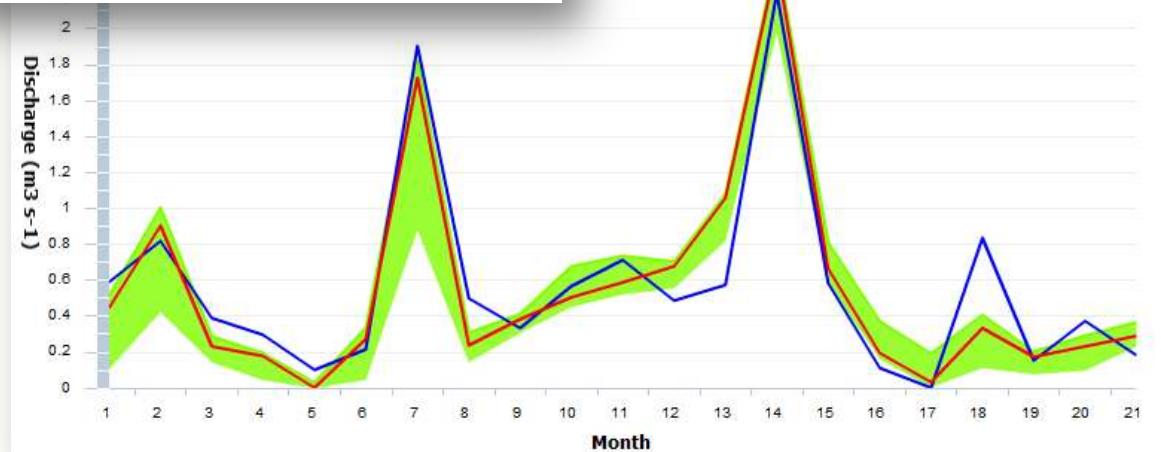
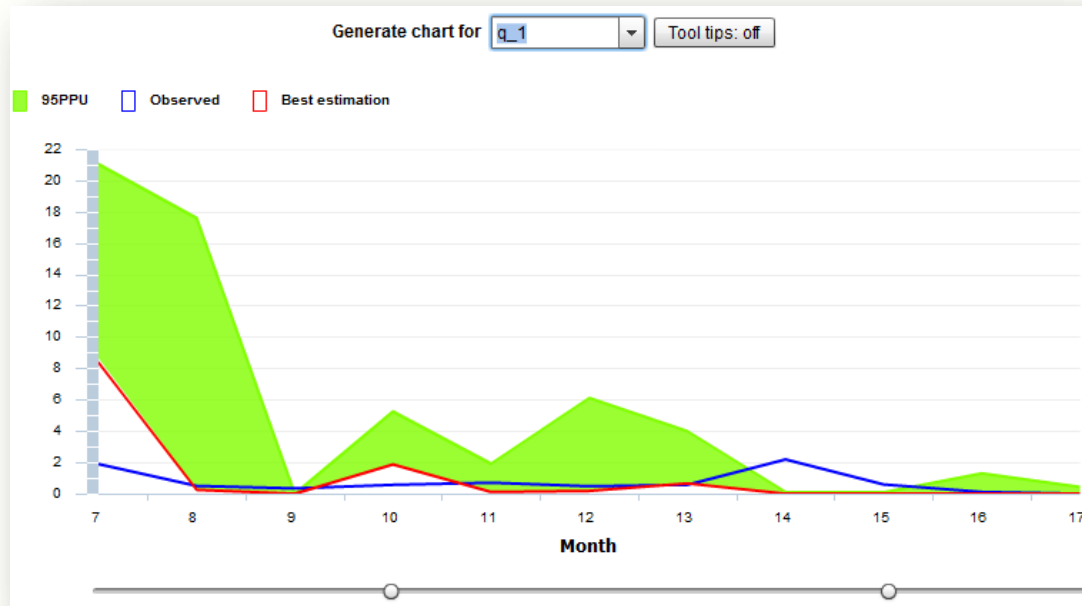
Project Explorer

- Executable Files
- Iterations history
- Calibration Inputs
 - file.cio
 - observed.sf2
 - str.sf2
 - trk.sf2
 - var_file_rch.sf2
 - par_inf.sf2
 - par_val.sf2
- Calibration Outputs
 - goal.sf2
 - new_pars.sf2
 - best_sim.sf2
 - 95ppu.sf2

par_inf.st

```
1 Test_example_2005
2
3
4
5 Number_of_Parameters= 10
6
7 Number_of_LH_sims= 15
8
9
10
11
12
13 r_CN2.mgt -0.1 0.1
14
15 v__ALPHA_BF.gw 0.0 0.08
16
17 v__GW_DELAY.gw 34 45
18
19 v__CH_N2.rte 0.0 0.08
20
21 v__CH_K2.rte 5 13
22
23 v__ALPHA_BNK.rte 0 1
24
25 r__SOL_AWC(1).sol 0.02 0.4
```

Calibration Output Visualization

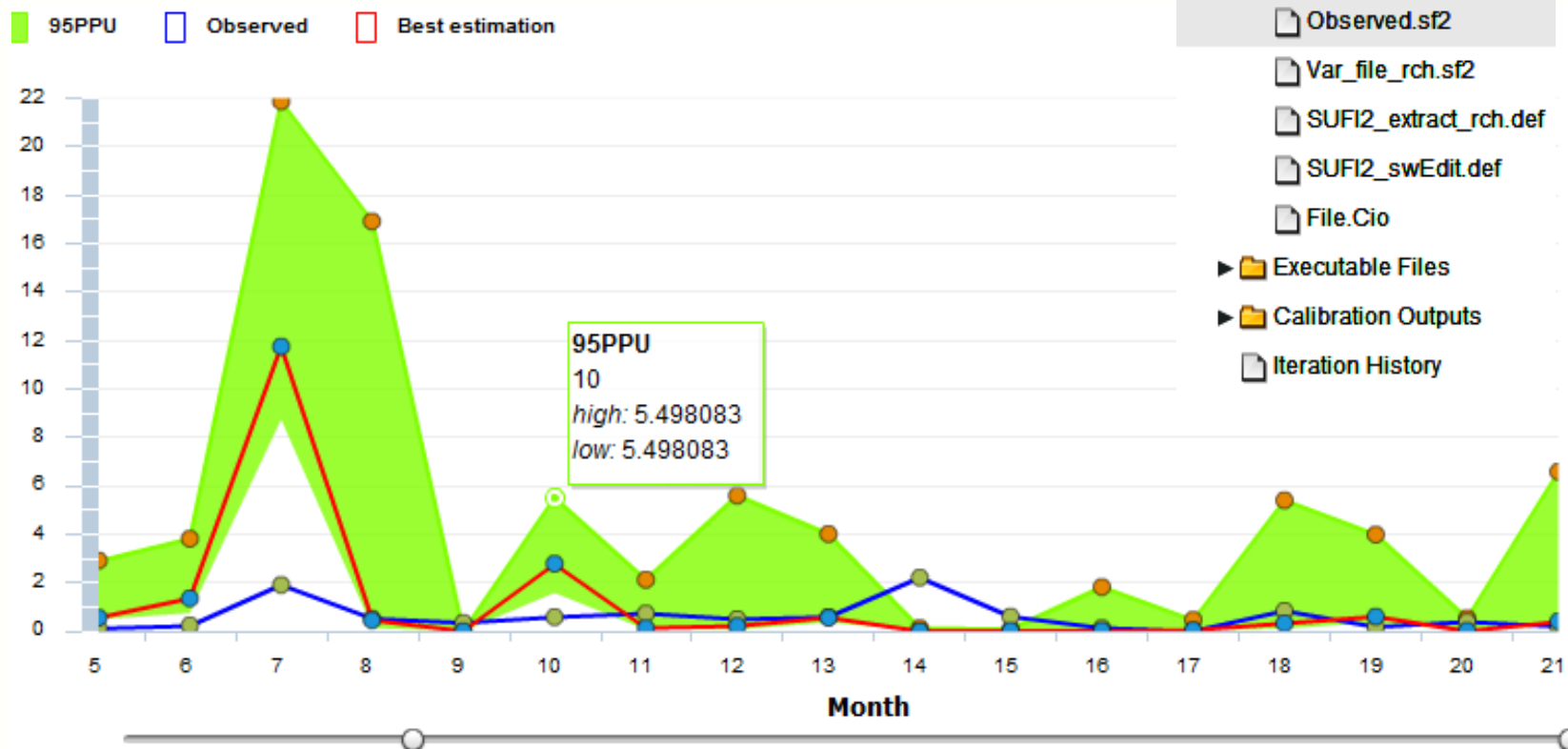


Calibration Output Visualization



Project Explorer

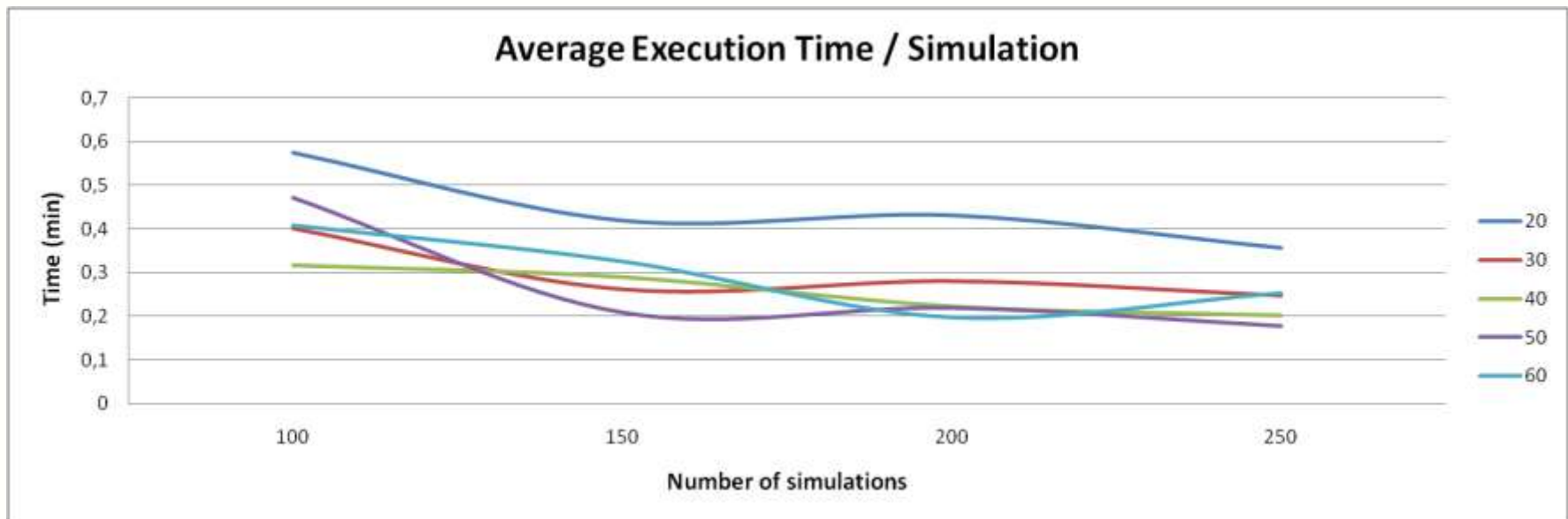
- ▼ Project2
 - ▼ Calibration Inputs
 - Par_inf.sf2
 - Observed.sf2
 - Var_file_rch.sf2
 - SUF12_extract_rch.def
 - SUF12_swEdit.def
 - File.Cio
 - ▶ Executable Files
 - ▶ Calibration Outputs
 - Iteration History



Performance



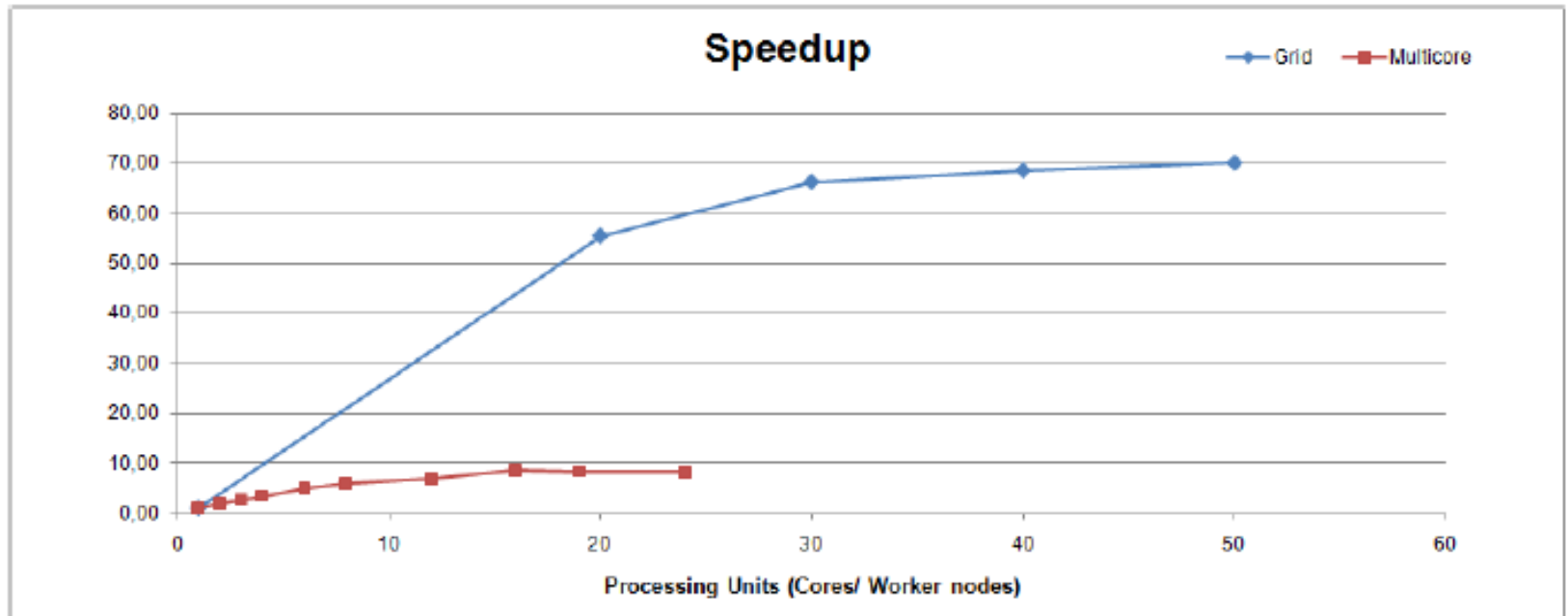
- vo.gear.cern.ch VO
- Variables:
 1. number of worker nodes
 2. number of SWAT simulations



Comparative Multicore vs Grid Speedup



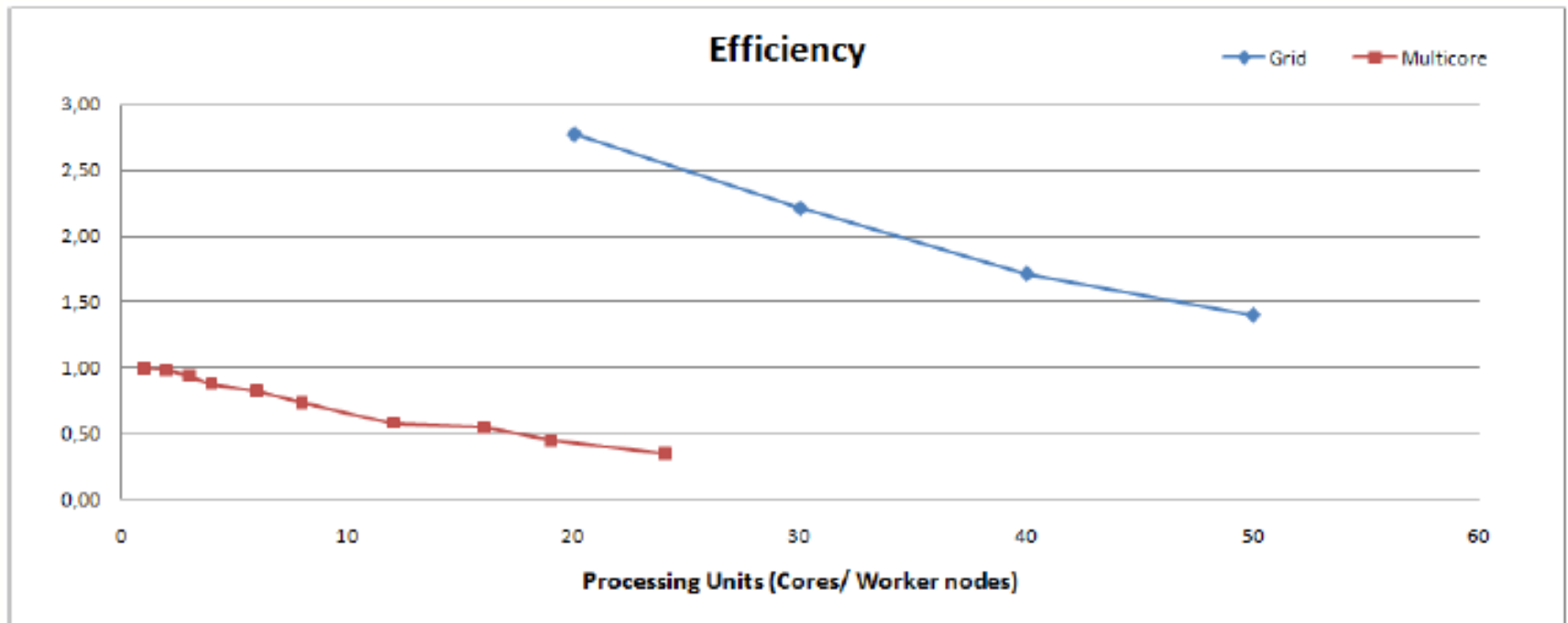
$$S(n) = T1/Tn$$



Comparative Multicore vs Grid Efficiency



$$E(n) = S(n)/n$$



Future work



- The possibility to define and run scenarios
- Export the calibrated SWAT model to other systems, such as BASHYT, for output visualization
- Parallel and distributed execution of the SWAT model on other platforms: Grid EMI, Cloud, Multicore, GPU based cluster

Thank you for your attention!

Questions?

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