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
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

BSC-OS Portal

Data Management Tools
Applications/ SWAT Scenarios
Visualization Tools
Decision Maker/ Citizen Tools

Geospatial and Grid Services

URM
SWAT (GANGA)
ESIP, gProcess
CWE (BASHYT)
Other Geospatial and Grid Technologies
eGLE

Geospatial Oriented Level

gLite Middleware

Grid Infrastructure (EGEE)

Data Repositories

- Spatial data, catalogues, maps
- Application data (hydrology, climate, soil, etc.)
- Scenarios
- Results of processing
Data Flow Throughout the Portal
Black Sea Catchment Basin

River Discharge (m³/sec)

<table>
<thead>
<tr>
<th>Watershed Q</th>
<th>Range</th>
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<tbody>
<tr>
<td>0 - 10</td>
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Soil & Water Assessment Tool | SWAT

2011 OpenWater symposium and workshops, UNESCO-IHE, Delft, The Netherlands, 18-19 April, 2011
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

![Diagram of gSWAT Overview]
gSWAT Functionalities

- 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

1. Pre-processing step
2. Simulation 1
   - Iteration n
   - Simulation n
3. Post-processing step
4. Test Calibration
5. Calibrated model
The calibration process

GRID

Iteration (1..n simulation steps)
gSWAT Application - Architecture

Web Portal
- SWAT Calibration
- SWAT Scenarios

SWAT Services
- Management and Execution
- Data Management
- Monitoring

Grid Infrastructure (gLite Middleware)
- Model repository
- Calibration outputs repository
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

Start the calibration process

The gSWAT services process the output data

Start the DIANE master

Start the GRID worker nodes Using GANNA

The DIANE master sends monitoring information to the Monitoring Component

The GRID WNs execute the tasks (simulations) and store the results on SE

The DIANE master sends monitoring information to the Monitoring Component

The gSWAT system

gSWAT GUI

gSWAT Services

DIANE master

Monitoring component

WNs

GRID related tools

gSWAT DB

GRID
gSWAT User Interface

- Project list and detailed information on the selected project

![Project list and detailed information on the selected project](image)
Create a new project

- Step 1: Define general project information

  Create a new project

  - Project name: Black Sea Catchment model
  - Project description: Calibrate the SWAT model that contains information about the Black Sea Catchment
  - TmxInOut created with: ArcSwat 2005

- Step 2: Select the SWAT model to be uploaded

  Upload project files

  - TmxInOut archive location: Complete path to archive (zip, rar, tar.gz)
Modify SUFI2 calibration parameters

![SUFI2 Calibration Interface]

- Project status: Finished iteration
- Project Explorer:
  - Executable Files
  - Iterations history
  - Calibration Inputs
    - file cio
    - observed.sfl2
    - str.sfl2
    - trk.sfl2
    - var_file_rch.sfl2
  - par_inf.sfl2
    - par_val.sfl2
  - Calibration Outputs
    - goal.sfl2
    - new_pars.sfl2
    - best_cycle.sfl2
    - 95ppu.sfl2
- Test_example_2005
- Number_of_Parameters = 10
- Number_of_IH_sims = 15
- Parameters:
  - r_CN2.mgt: -0.1 0.1
  - v_ALPHA_BF.gw: 0.0 0.08
  - v_QW_DELAY.gw: 34 45
  - v_CH_N2.re: 0.0 0.08
  - v_CH_K2.re: 5 13
  - v_ALPHA_BNK.re: 0 1
  - r_SOL_AWC(1).sol: 0.02 0.4
Calibration Output Visualization
Calibration Output Visualization
Performance

- vo.gear.cern.ch VO

- Variables:
  1. number of worker nodes
  2. number of SWAT simulations
Comparative Multicore vs Grid Speedup

\[ S(n) = \frac{T_1}{T_n} \]
Comparative Multicore vs Grid Efficiency

\[ E(n) = \frac{S(n)}{n} \]
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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