

MINISTRY OF EDUCATION AND RESEARCH



TECHNICAL UNIVERSITY
OF CLUJ-NAPOCA

CGIS
Computer Graphics
and Interactive Systems

gSWATCloud workshop

SWAT Models Calibration over Cloud Infrastructures

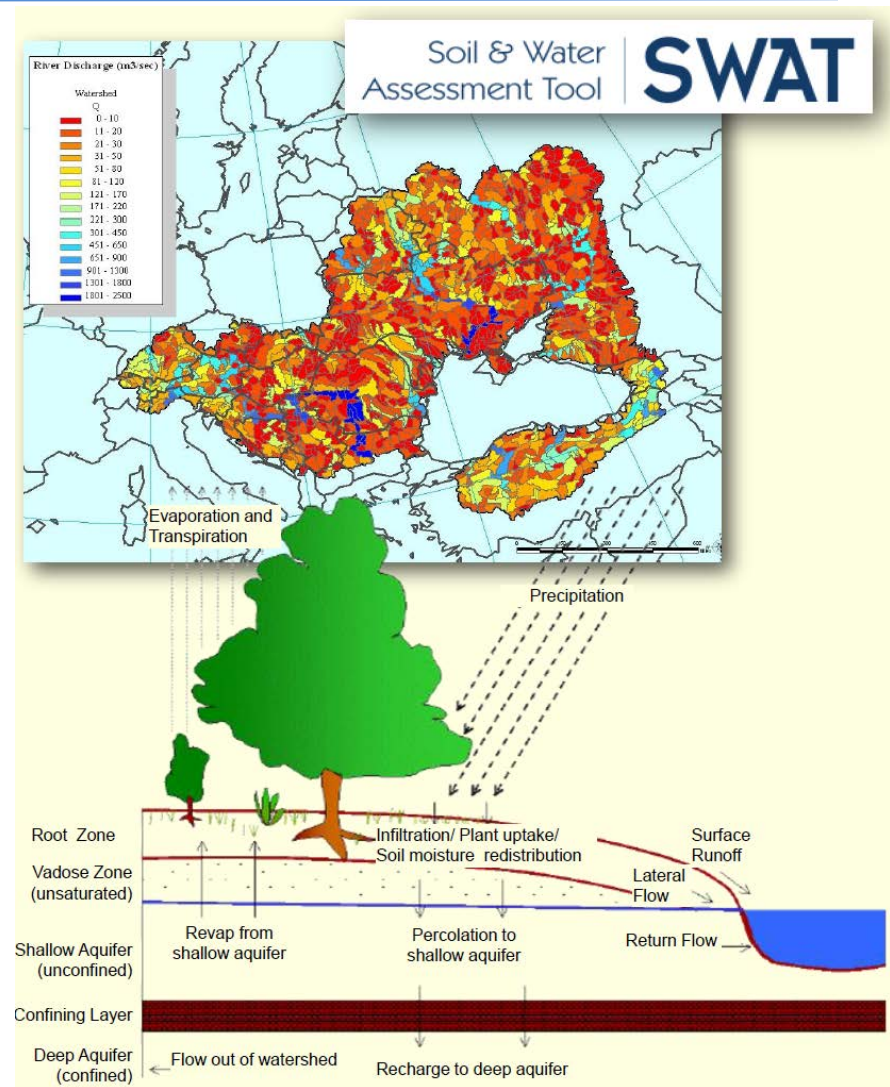
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Constantin Nandra, Teodor Stefanut
Computer Science Department,
Technical University of Cluj-Napoca
<http://cgis.utcluj.ro>

Overview

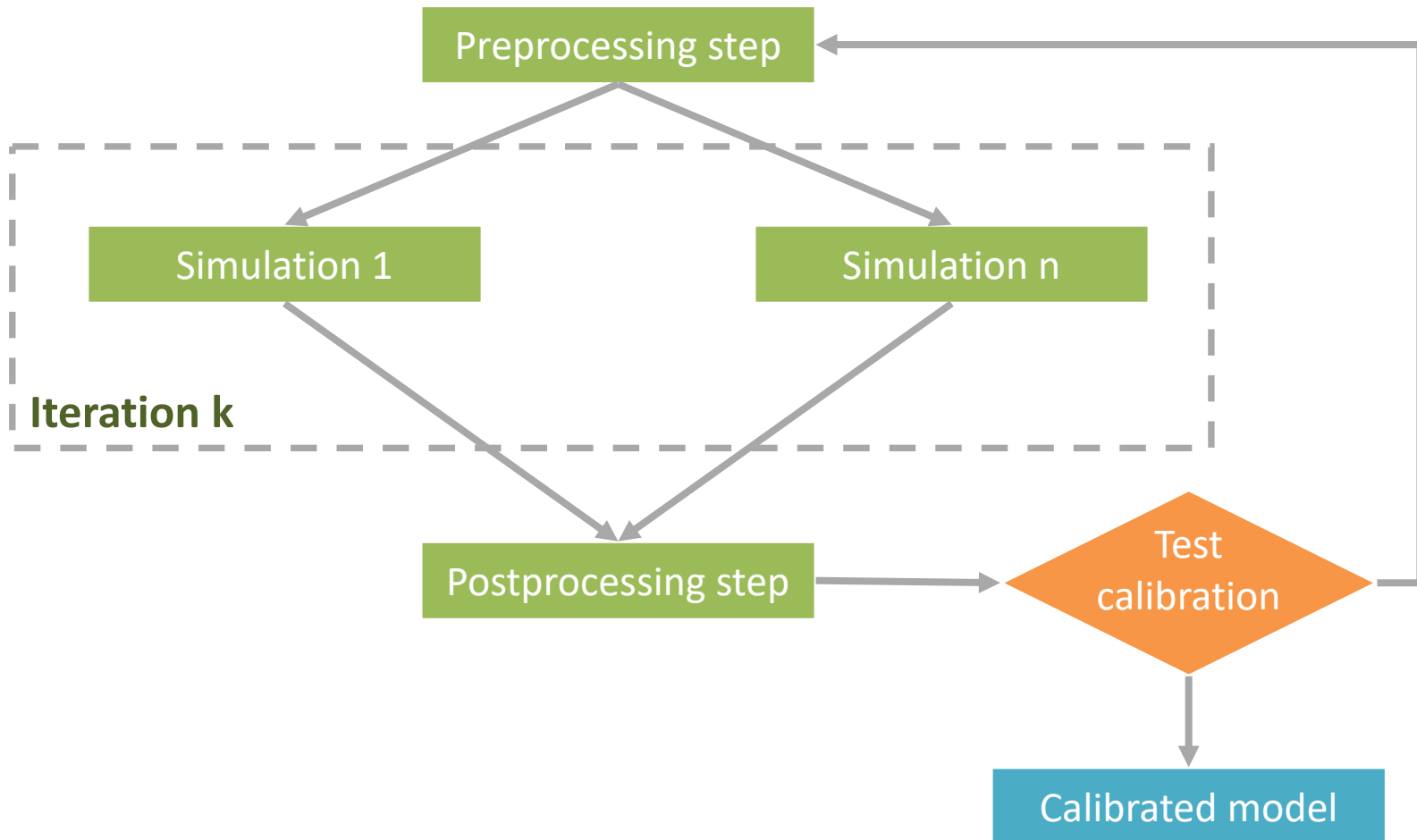
- SWAT models
- Calibration process
- Issues
- Parallel approach
- gSWATCloud platform
- Evaluation
- Conclusions

SWAT models

- 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



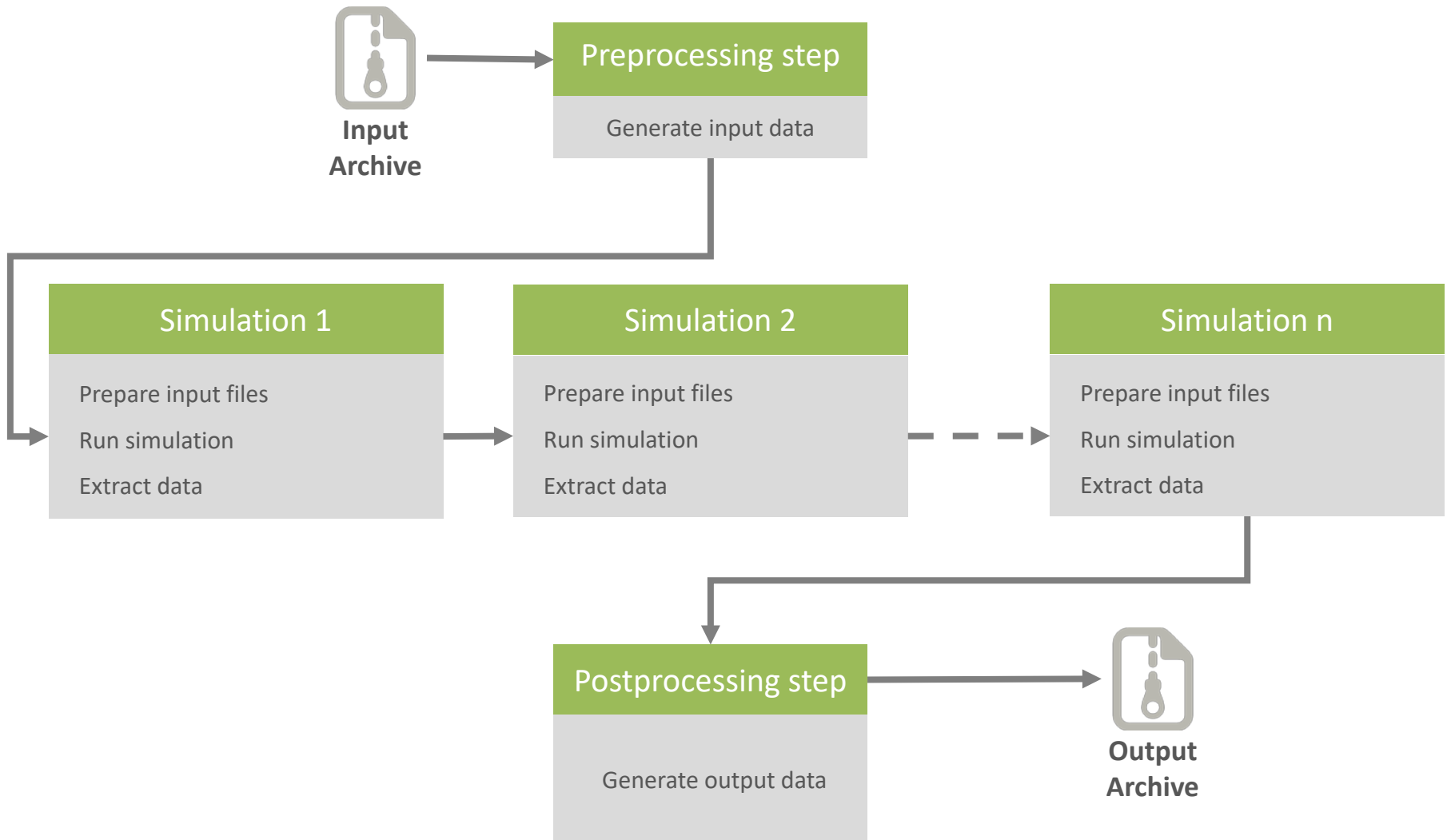
Calibration process



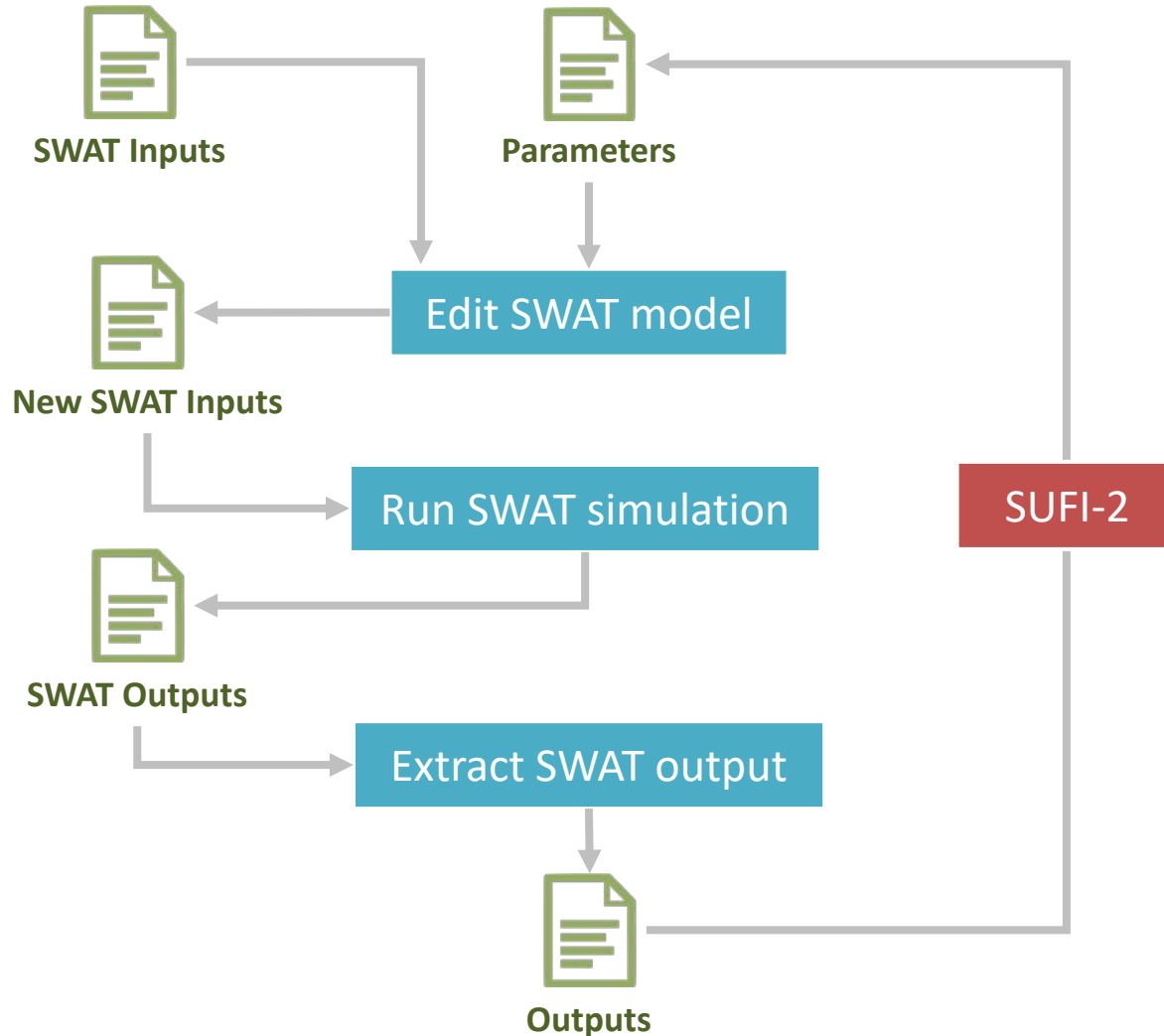
Calibration process

- *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 other simulations
- 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

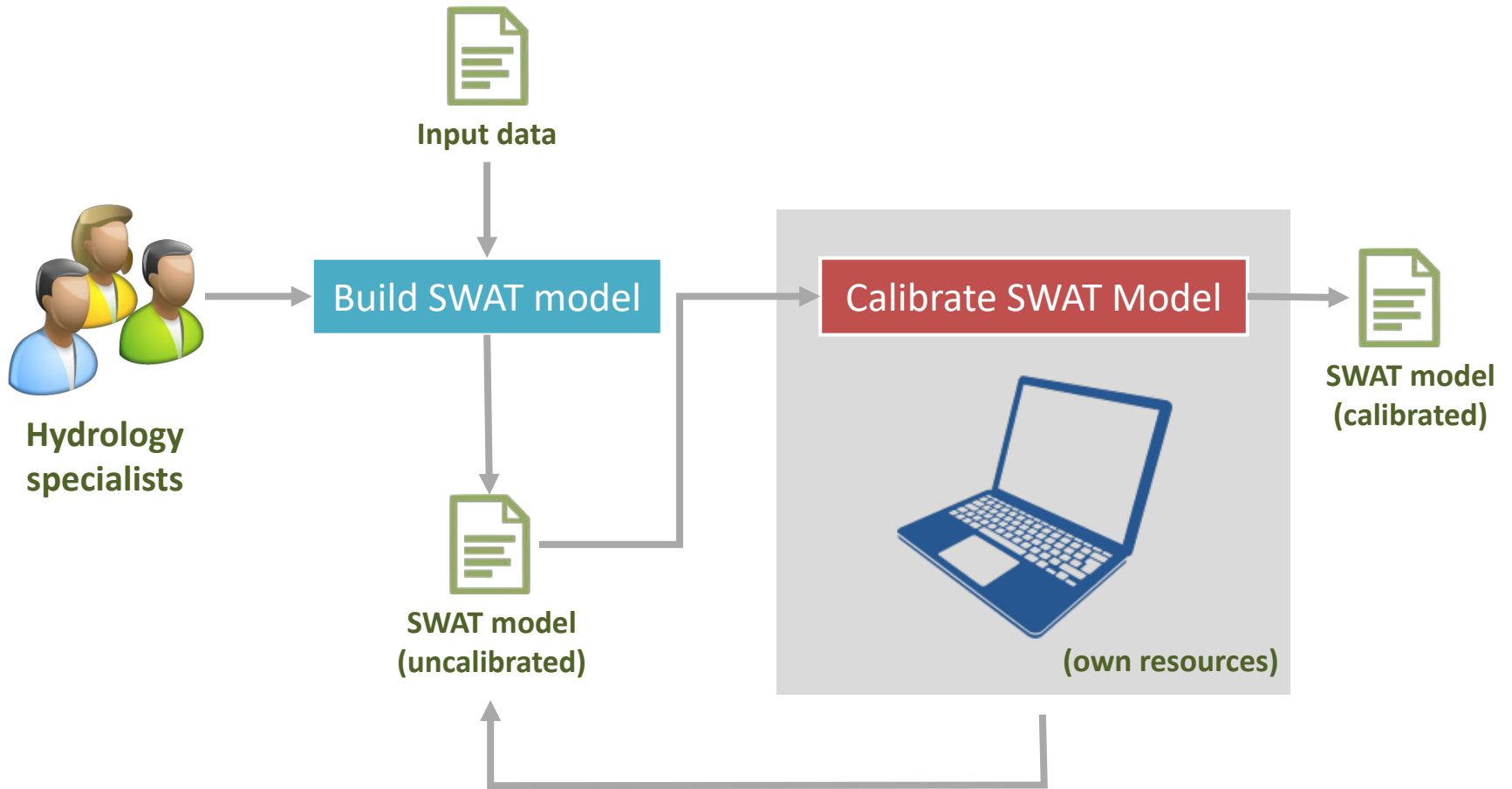
Calibration process - sequentially



Calibration process



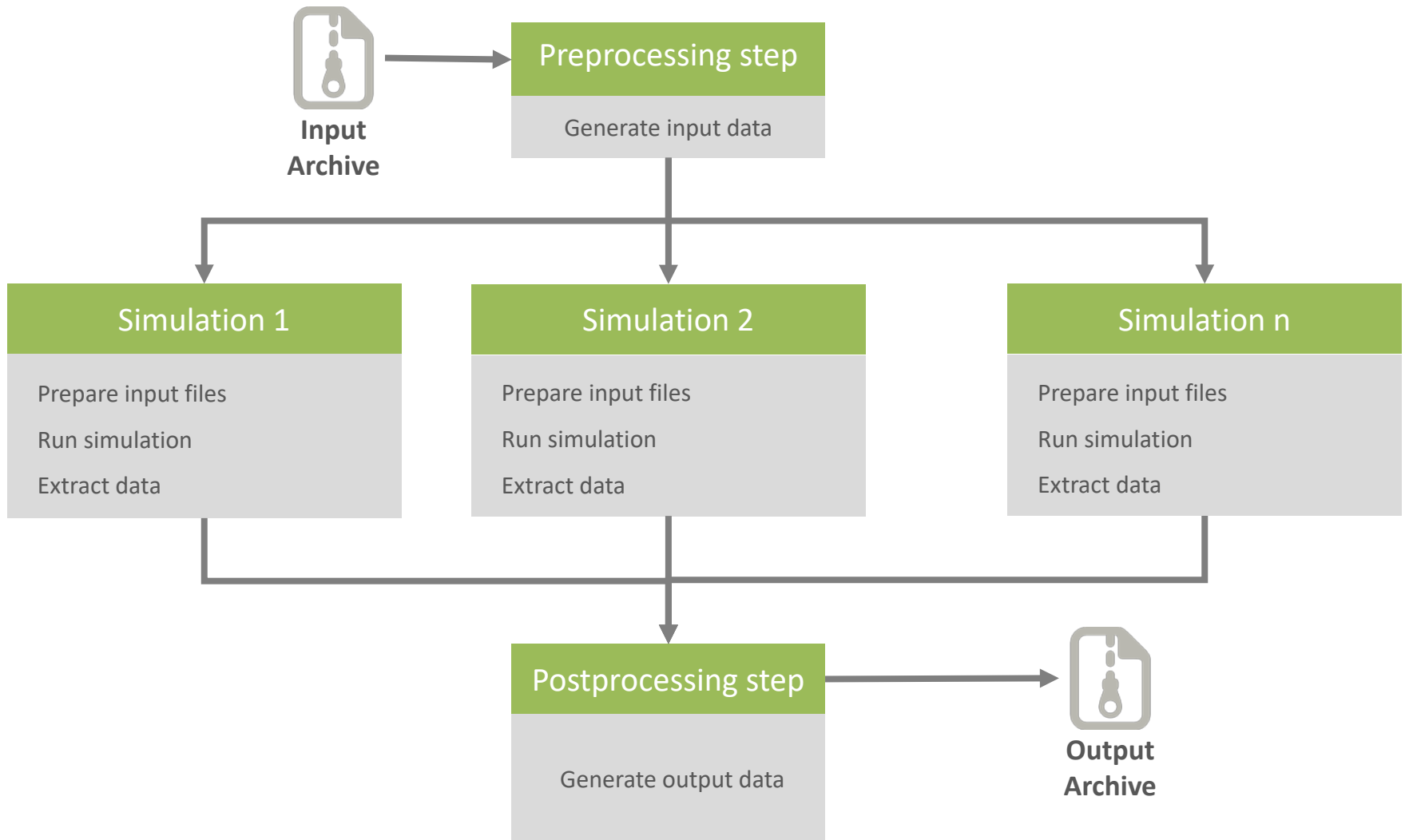
SWAT model calibration



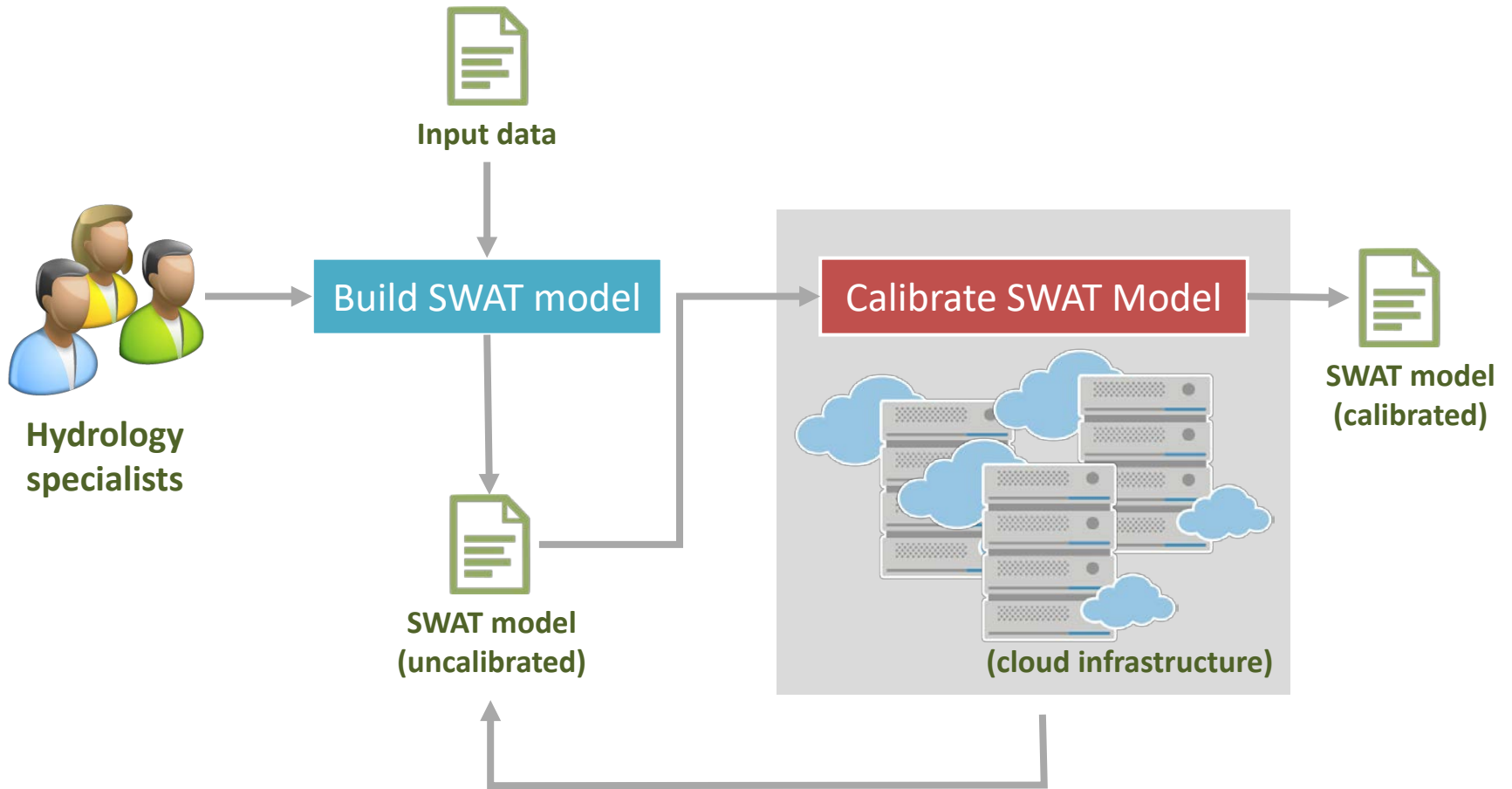
Issues

- Complex SWAT models
 - Need higher computational resources
 - Increase execution time
- Use own resources
- Must run simulations sequentially (parallel/#cores)
- Difficult to run multiple calibration processes on the same resources in the same time (multi-models)

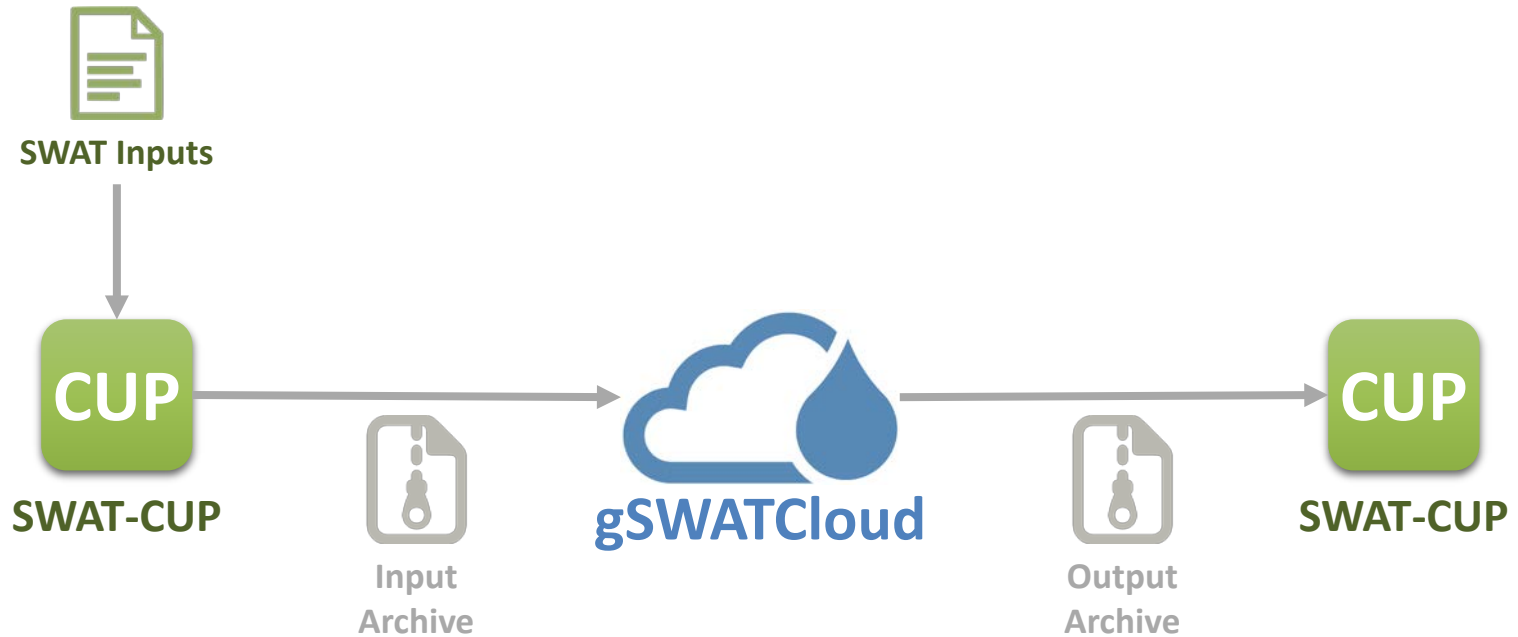
Calibration process - parallel



Distributed approach



gSWATCloud



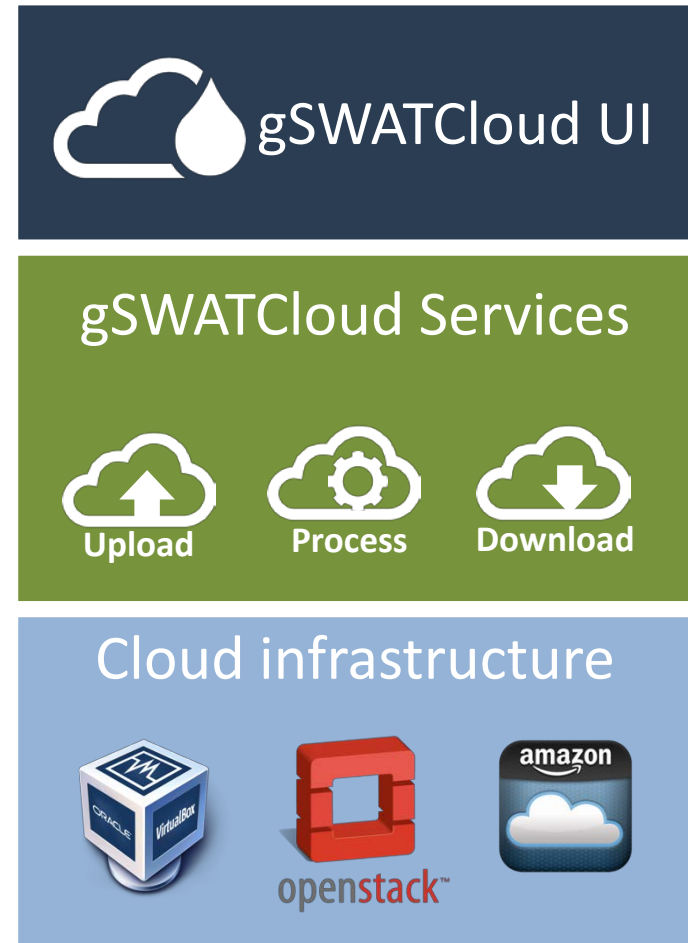
Define calibration
parameters

Run the calibration
process

Visualize
results

gSWATCloud platform

- Calibration and execution of SWAT model
 - Multiple SWAT models
 - Multiple users
 - Parallel and distributed approach
 - Accessible through a Web browser



gSWATCloud User Interface

- Simple and intuitive interface
- Runs through Web browser
- No plugin required
- Functionality:
 - Upload SWAT models
 - Visualize the execution progress
 - Download results



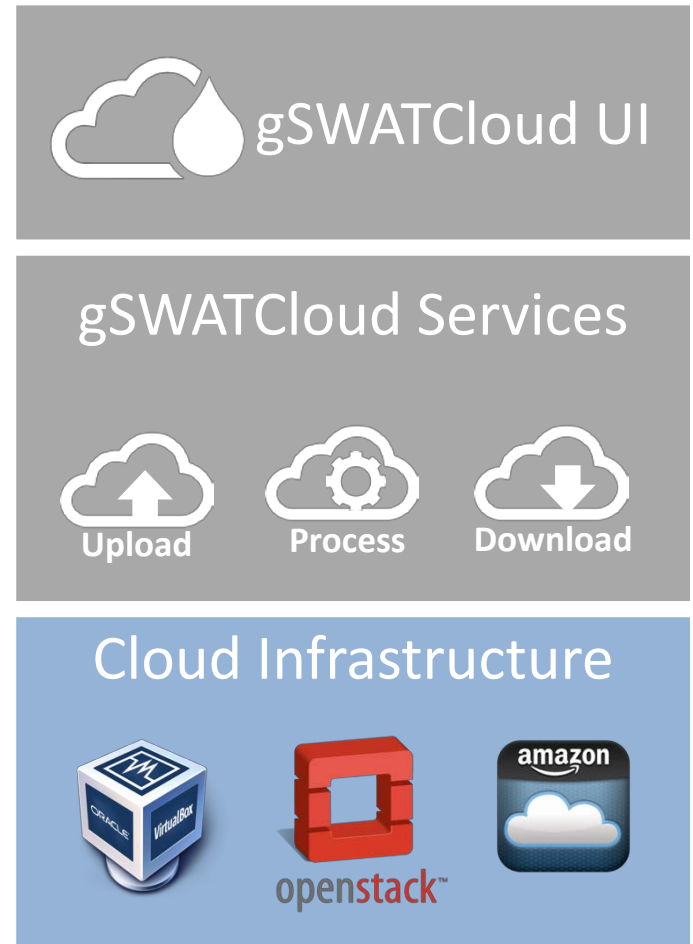
gSWATCloud Services

- Web services
- Can be used by other applications
- Based on BIGEARTH platform
 - Process description + execution
- Exposed services:
 - Upload model
 - Process model
 - Download results



Cloud Infrastructure

- Distributed resources
- Transparent for the users
- Performance depends on the number and capacity of resources

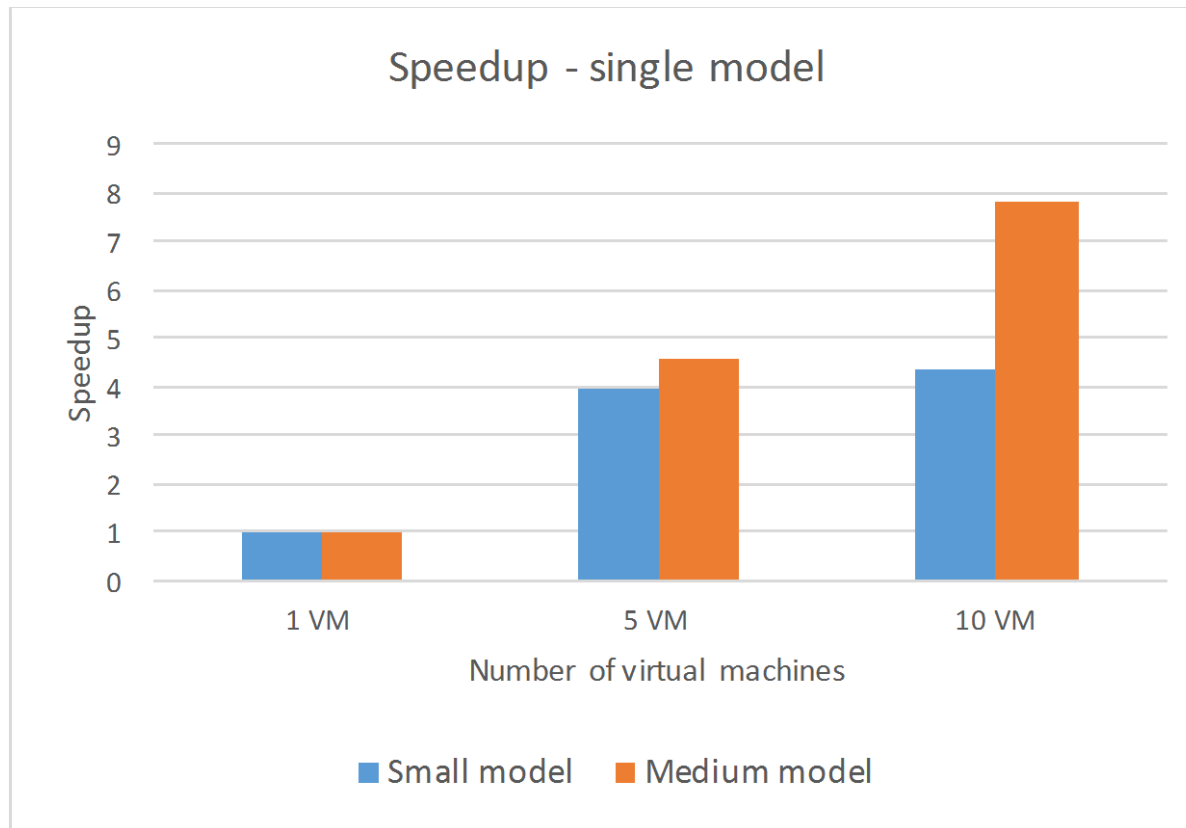


Performance evaluation

- Speedup
 - $S(n)=T_1/T_n$ - is the speedup for n available computation resources;
 - T_1 is the total computation time on single processor
 - T_n is the total computation time on n processors
- Small SWAT model (i.e. data model size) ~ 20MB
 - Local execution time: ~ 6min
 - 10 simulations
- Medium SWAT model ~ 200MB
 - Local execution time: ~ 2h 30min
 - 10 simulations

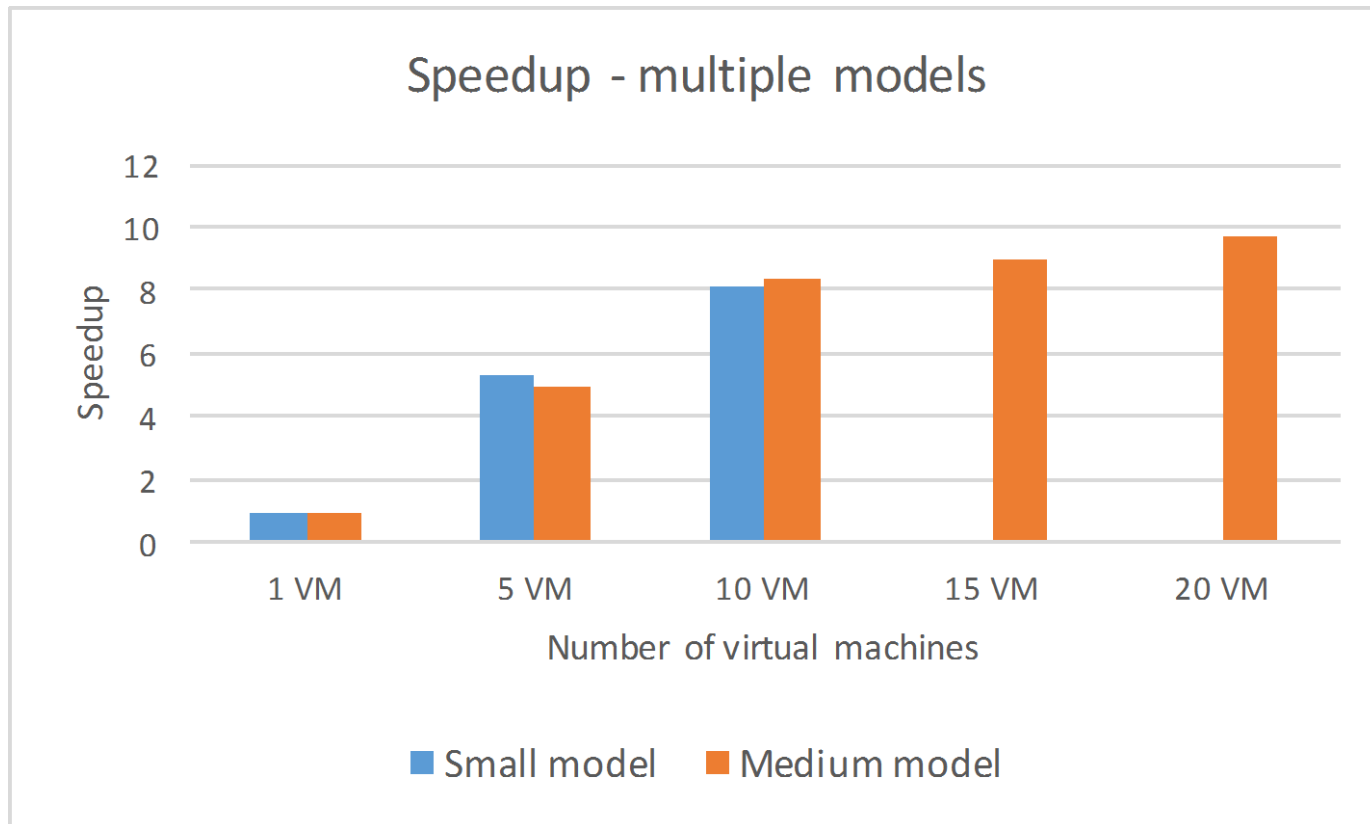
Performance evaluation

- Single user
- Single SWAT model execution: 10 simulations/Small SM, Medium SM
- Computing resources: 1 - 10 VM



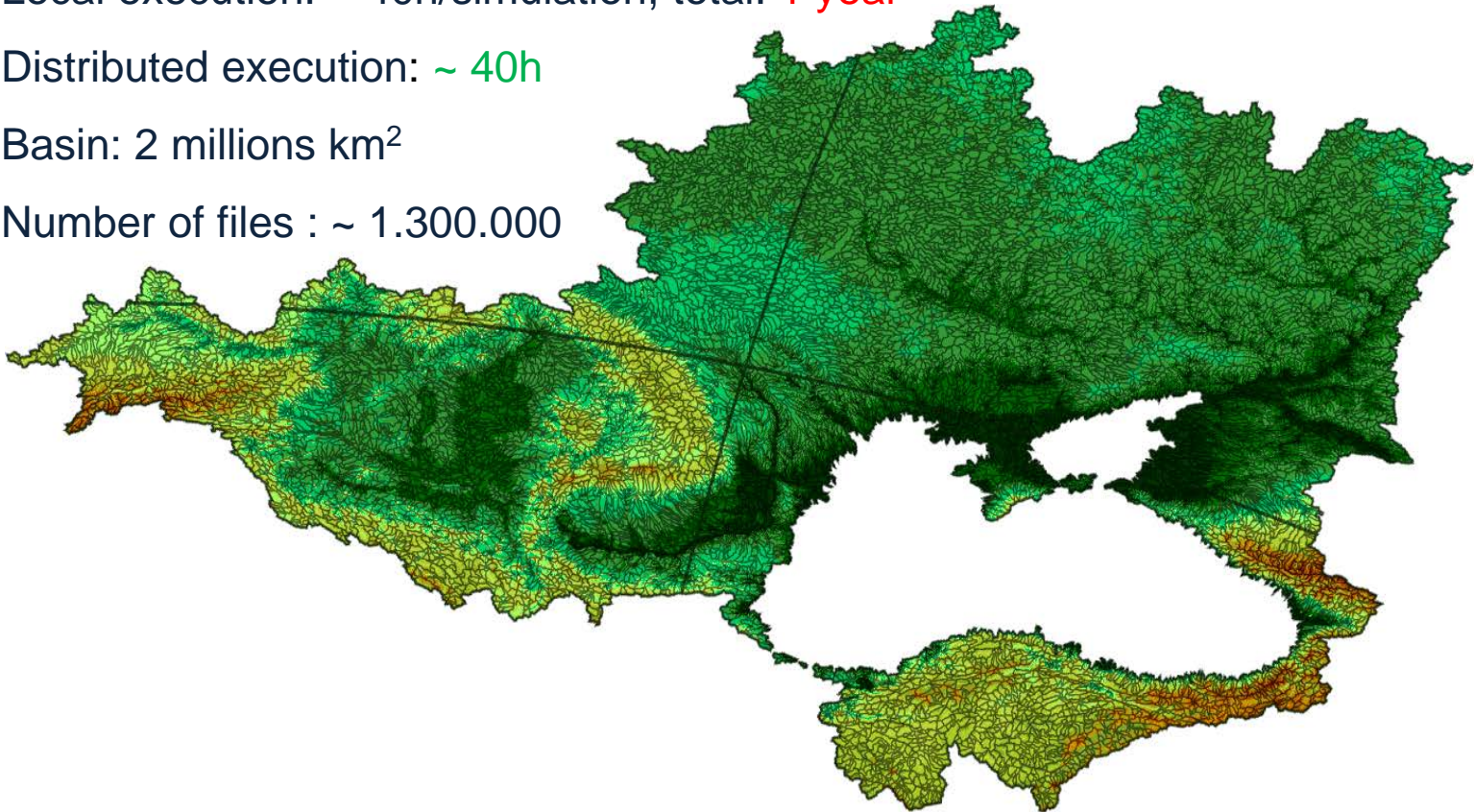
Performance evaluation

- Multiple users: 5
- Multiple SWAT models: 5 (10 simulations/Small SM, Medium SM)
- Computing resources: 1 - 20 VM



Example of calibration results

- Black Sea catchment
- 200 simulations
- Local execution: ~ 40h/simulation, total: **1 year**
- Distributed execution: ~ 40h
- Basin: 2 millions km²
- Number of files : ~ 1.300.000



gSWATCloud demo

The screenshot shows a web browser window with the URL `gswat.utcluj.ro`. The page title is "gSWATCloud - Projects". The interface features a dark blue sidebar on the left with the following elements:

- gSWATCloud logo
- Welcome, Victor Bacu (with a user profile icon)
- Current projects (with a menu icon)
- Create new project (with a pencil icon)
- Log out (with a power icon)

The main content area is titled "Current projects" and displays the following information:

- Last update: Mar 0, 2017 13:19:33 PM
- A table with columns: Project Information, Project Progress, and Status.

Project Information	Project Progress	Status
SWAT model Created: Mar 19, 2017 1:18:31 PM SWAT model description	<div style="width: 50%;"><div style="width: 50%;"></div></div> 5 / 10 simulations complete	running Edit Delete

gSWATCloud demo

The screenshot shows a web browser window with the URL `gswat.utcluj.ro`. The page title is "gSWATCloud - Projects". The interface features a dark blue sidebar on the left with the gSWATCloud logo and a user profile for "Victor Bacu". The main content area is titled "Current projects" and displays a table of project information. The table has three columns: "Project Information", "Project Progress", and "Status". A single project, "SWAT model", is listed. It was created on "Mar 19, 2017 1:18:31 PM" and is currently "running". The progress bar shows "9 / 10 simulations complete". There are "Edit" and "Delete" buttons for this project. A notification at the bottom of the browser window says "Open 'https://gswat.utcluj.ro:8443/projects-view.html' in a new tab".

Project Information	Project Progress	Status
SWAT model Created: Mar 19, 2017 1:18:31 PM SWAT model description	<div style="width: 90%;"><div style="width: 90%;"></div></div> 9 / 10 simulations complete	running Edit Delete

gSWATCloud demo

The screenshot shows a web browser window with the URL `gswat.utcluj.ro`. The page title is "gSWATCloud - Projects". The interface features a dark blue sidebar on the left with the following elements:

- gSWATCloud logo
- User profile: "Welcome, Victor Bacu" with a circular avatar icon.
- Menu items: "Current projects" (highlighted) and "Create new project" (with a pencil icon).
- Logout button: "Log out" with a power icon.

The main content area is titled "Current projects" and displays a table of project information. The table has three columns: "Project Information", "Project Progress", and "Status".

Project Information	Project Progress	Status
SWAT model Created: Mar 19, 2017 1:18:31 PM SWAT model description	Execution completed on: Mar 19, 2017 1:20:04 PM	completed Download results Delete

Additional text on the page includes "Last update: Mar 0, 2017 13:21:11 PM" in green text above the table.

Conclusions

- gSWATCloud application and platform
- Calibration and execution of multiple SWAT models
- Multiple users
- Parallel and distributed approach
- Accessible through the Web browser
- Interact and collaborate with SWAT-CUP application through the input and output files of a SWAT model

CGIS Research Team

- Computer Graphics and Interactive Systems

Research Lab. (<http://cgis.utcluj.ro>)

- Computer Science Department

- Technical University of Cluj-Napoca

(<http://www.utcluj.ro>)

- CGIS expertise:

- computer graphics, user interaction techniques, graphics modelling and simulation;
- distributed interactive application development methodologies, Cloud, Grid, and GPU applications development, and HPC based processing and visualization;
- Earth Observation and Earth Science applications development.



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Thanks for attending the presentation!

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