Modeling frameworks - A basis for building decision support systems on river basin scale, the OMS and JAMS cases

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Introduction to OMS (1/2)

- The Object Modeling System (OMS) is a framework and development kit for designing, building, validating, and deploying water resources and agro-environmental models. It contains four platforms:
  - Model Development
  - Model Deployment (Cloud Services)
  - Data Provisioning
  - Knowledge Base (Component Repository)

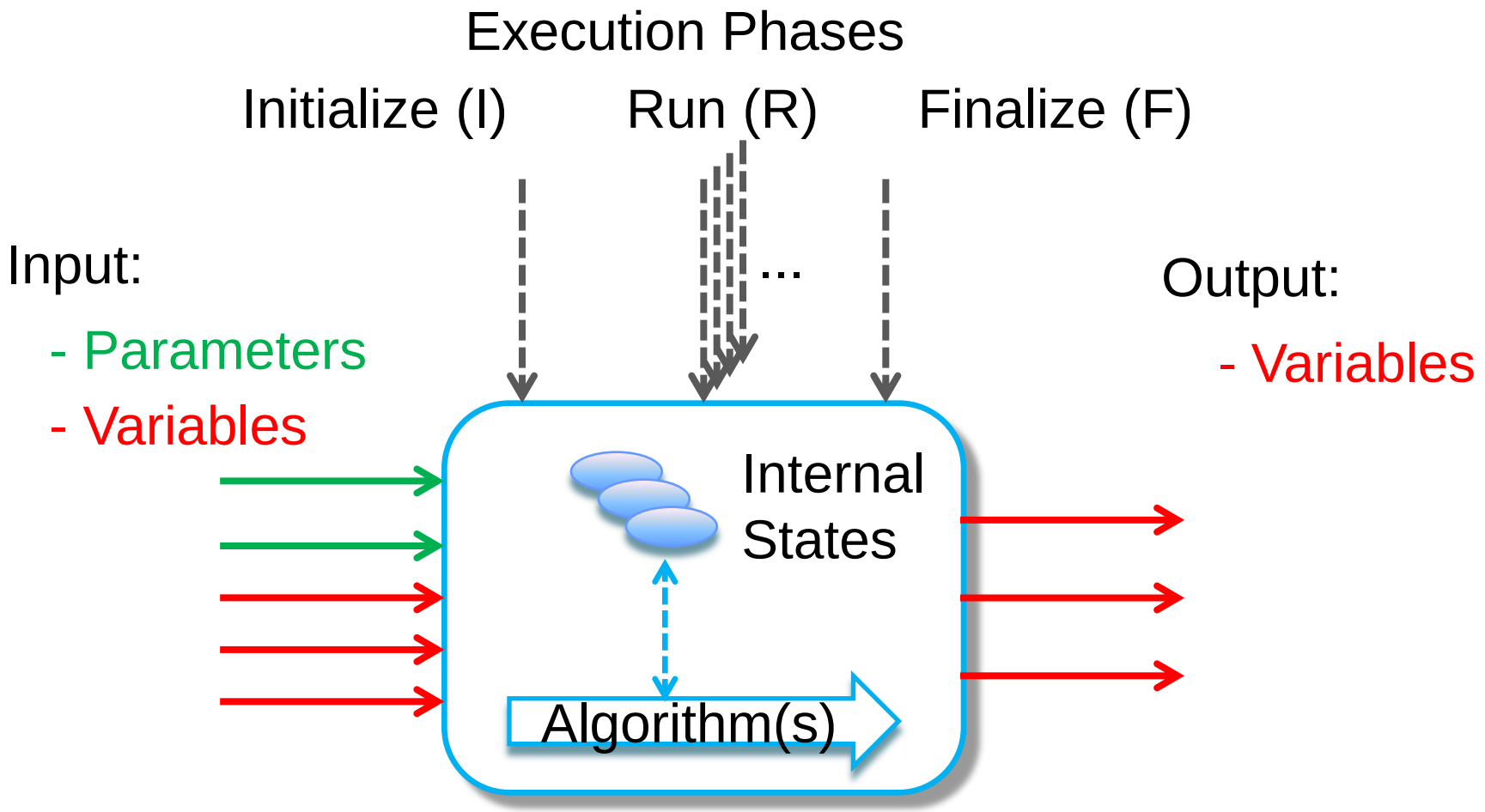
Introduction to OMS (2/2)

- OMS is a pure Java, object-oriented modeling framework
- OMS is a lightweight, non-invasive framework
- OMS allows model construction and model application based on components
- It is a collaborative project active among the U.S. Department of Agriculture, US Geological Survey and partner agencies and organizations involved with water resources and agro-environmental modeling.
- Internet: http://www.javaforge.com/project/oms
- The Jena Adaptable Modeling System (JAMS) is a similar framework, Internet: http://jams.uni-jena.de

Components and Models (1/7)

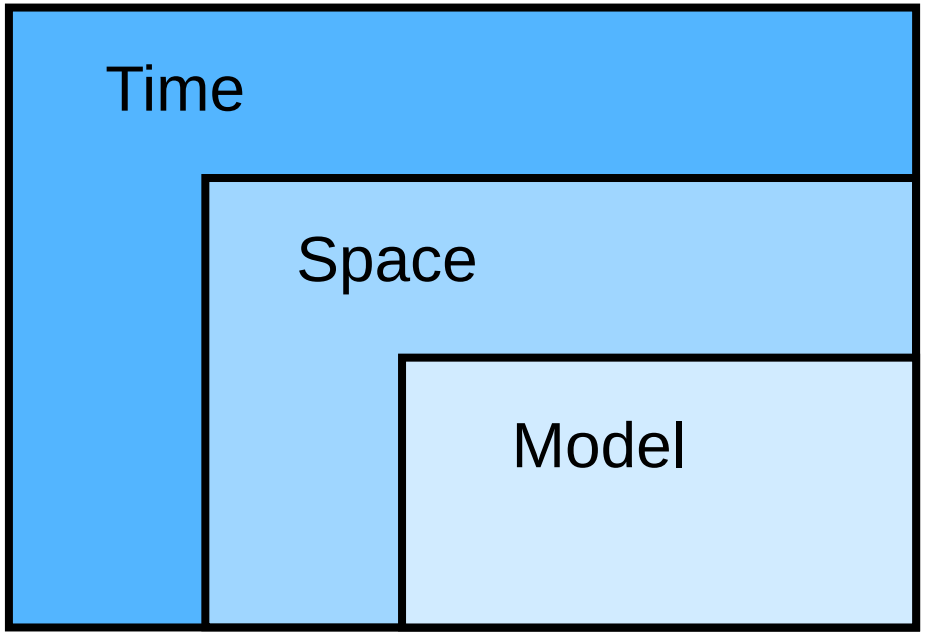
- OMS is component-based. A component is the smallest building block for models, e.g. evapotranspiration according to Penman-Monteith.
- A component is a self contained software unit that is well separated from its environment.
- Components are reusable modeling entities.
- Components are based on a common “life cycle”: Initialize, Run (Execute), Finalize“ -> (IRF)
- Components are building blocks for models
- Annotations are used to specify resources within a class that relate to its use as a modeling component for OMS
- Models are derived by “connecting” different components together

Components and Models (2/7)
OMS General Component Scheme

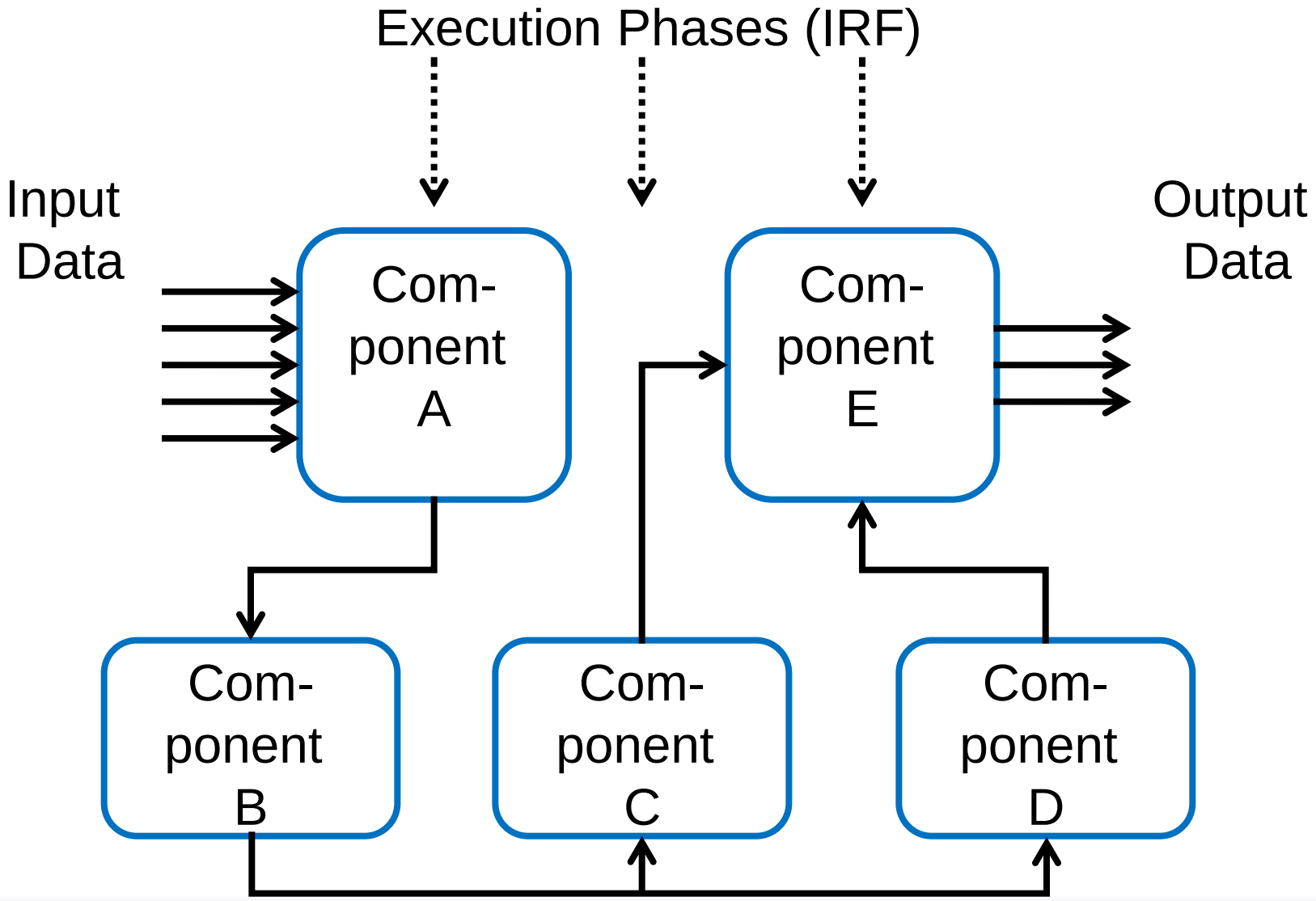


Components and Models (3/7)

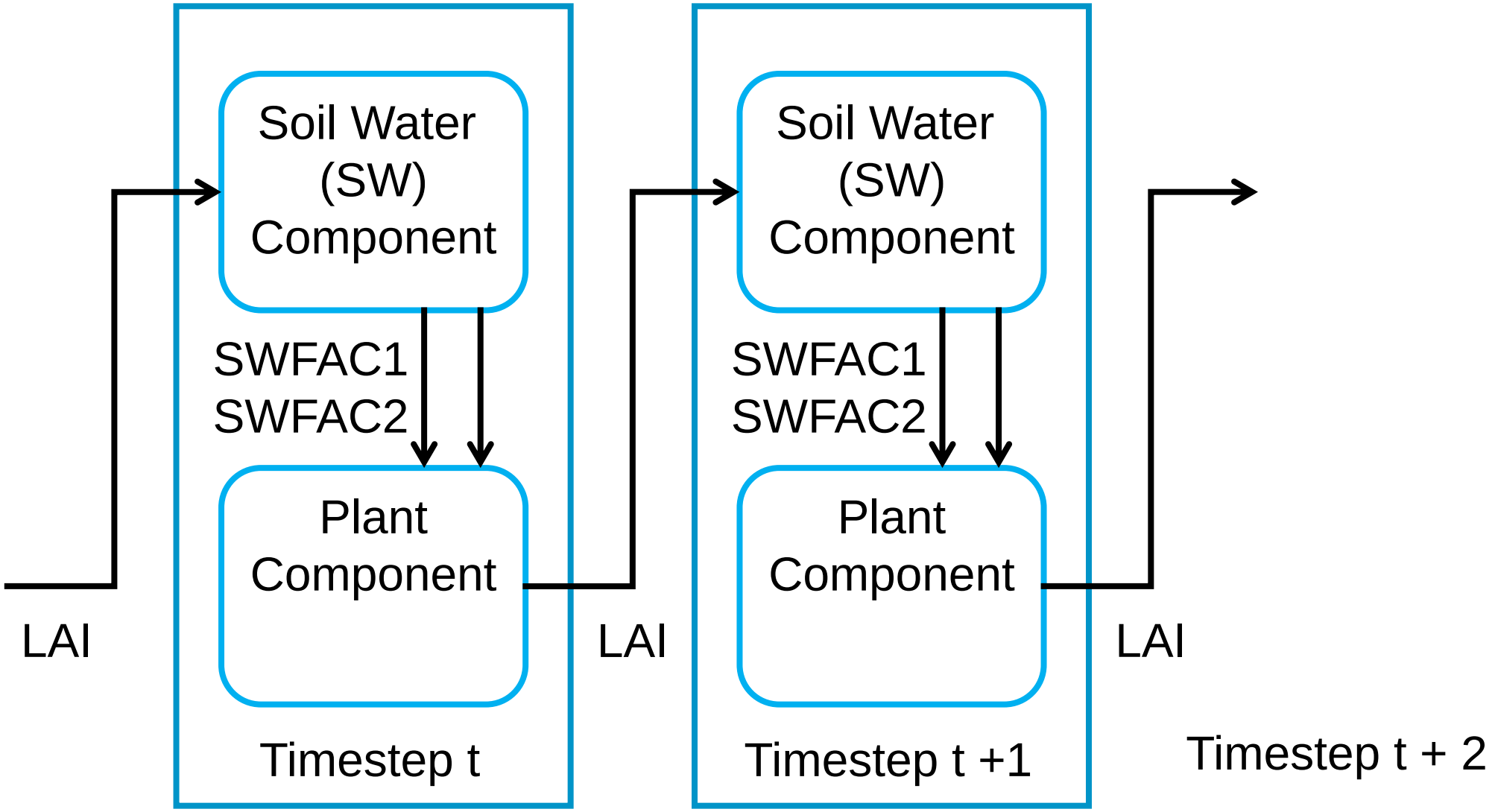
- Simulation (Execution) sequences in OMS:



Components and Models (4/7)
Connecting Components



Components and Models (5/7)
Feedbacks Between Timesteps



Components and Models (6/7)
Built-in Features

- Create model simulations for verification testing, calibration, validation, and analysis, including:
  - LUCA calibration (shuffled complex evolution)
  - DDS (Dynamically Dimensional Search) calibration
  - FAST (extended Fourier Amplitude Sensitivity Test) sensitivity analysis
  - and others ...

Components and Models (7/7)
Existing Models / Components

- Thornthwaite Monthy Water Balance Model
- Precipitation Runoff Modeling System (PRMS/OMS)
- AgroEcoSystem-Watershed Model (AgES-W)
- JGrasstools
- J2000 Hydrological Model
- Catchment Model (CATMO)
- Others ..., all in all about 200 components
- Interface to OpenMI

Decision Support Systems (1/2)

- Loucks (1995) defines a DSS simply as an “interactive computer-based information provider.”
- The common objective of all DSSs according to Loucks, is to “provide timely information that supports human decision makers – at whatever level of decision making.”
- DSSs can be setup in different ways:
  DSSs can be either fully computerized, human or a combination of both.

Decision Support Systems (2/2)
DSS Components

- A DSS can contain many different components and capabilities, depending on the structure and comprehensiveness. Some relatively common components and capabilities listed by Loucks (1995) and Simonovic (1996) are:
  - Analytical models or algorithms (simulation and/or optimization)
  - Database module(s) and data retrieval processes
  - Graphics and visualization tools
  - Spatial analysis – GIS
  - User-friendly computer interactions or interfaces
  - ...

DSS for the Management of Hydraulic Works (1/4)

- The Vietnam Ministry of Agriculture and Rural Development is currently in the process of designing and developing a DSS for managing Hydraulic Works of irrigation/drainage systems servicing areas bigger than 200 ha
- The aim is to improve the operational efficiency of the state management agencies as well as the operation and management agencies at central and local levels
- The project is aided by GIZ in the context of its Climate Change and Coastal Ecosystems Cluster project
- The project started in late 2012, it is anticipated that until the end of 2015 pilot applications for 3 test sites (Quan lo - Phung Hiep, Bac Hung Hai and Krong Buk Ha Water Management Systems) will be at hand

DSS for the Management of Hydraulic Works (2/4)

Statistical data in the context of Hydraulic Works for Vietnam:

- 904 irrigation/drainage systems servicing areas bigger than 200 ha (110 are bigger than 2.000 ha)
- Thousends of irrigation/drainage systems servicing areas smaller than 200 ha

- 6.648 reservoirs
- 10.100 weirs
- 13.350 pumping stations
- 5.500 sluices/gates
- 10.782 other small or temporary structures

DSS for the Management of Hydraulic Works (3/4)

Potential users/beneficeries of the system include:

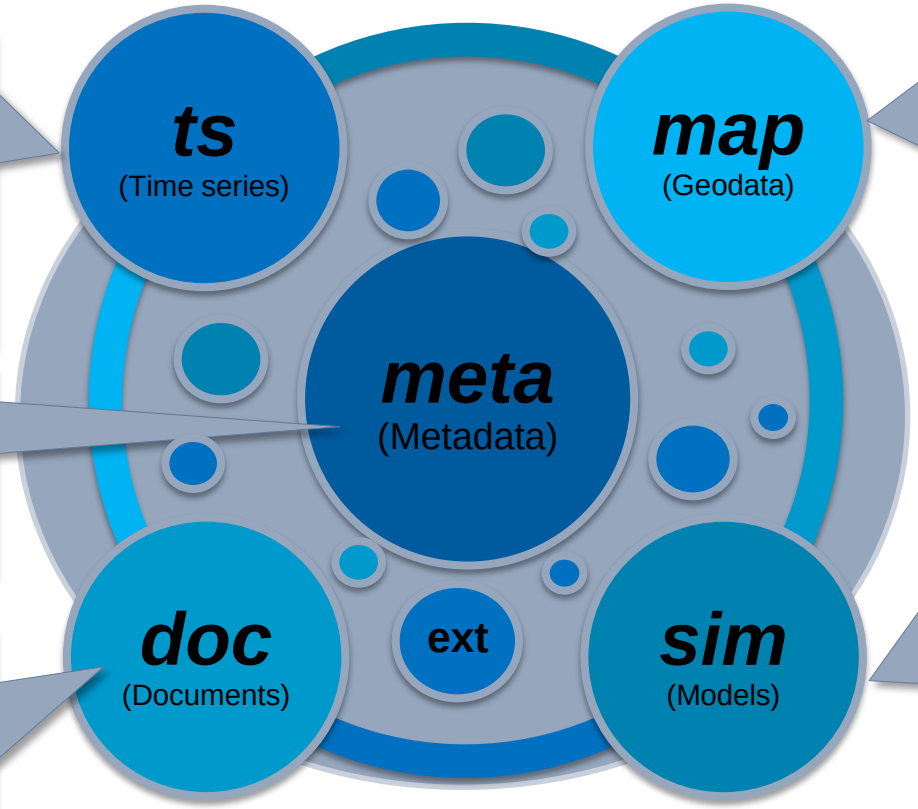
- Ministry of Agriculture and Rural Development
- 63 Departments of Agriculture and Rural Development at provincial level
- 697 Departments of Agriculture and Rural Development at district level
- 11.112 units of transport and water resources at communal level

DSS for the Management of Hydraulic Works (4/4)

- The DSS for operating and managing of Hydraulic Works will consistently manage all data in a single database system / file system
- The system is anticipated to be web-based, no special hardware nor special software installations – except for a web browser - will be required
- The user interface will comprise GIS functions for retrieving and managing/editing geodata objects as well as displaying data against a geographical background (mapping)
- Hydro-metereological data are the basis for operating decisions, in this context OMS could be used for simulation purposes
- System requirements are presently being compiled

Integrated Landscape Management System (ILMS) (1/7)

Storage → Visualization → Analysis → Decision Support



Time series
- Simulated and measured time series
- Data source description

Metadata
… based on ISO19115 for all datasets

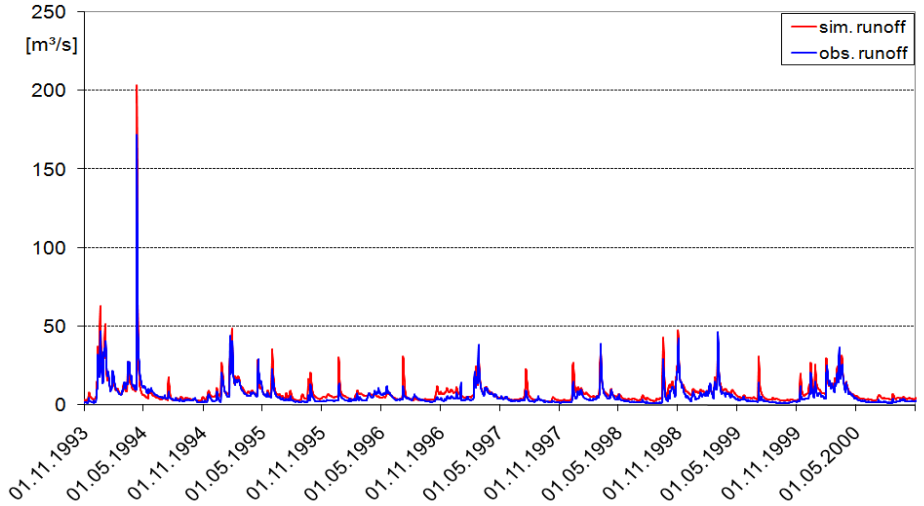
Documents
- Text documents (PDF, …)
- Pictures
- Raw/binary files

Geodata
- User-defined, interactive maps
- Vector and raster data
- Web-mapping services

Environmental Models
- Scenario management
- Model management & application
- Indicator calculation for decision support

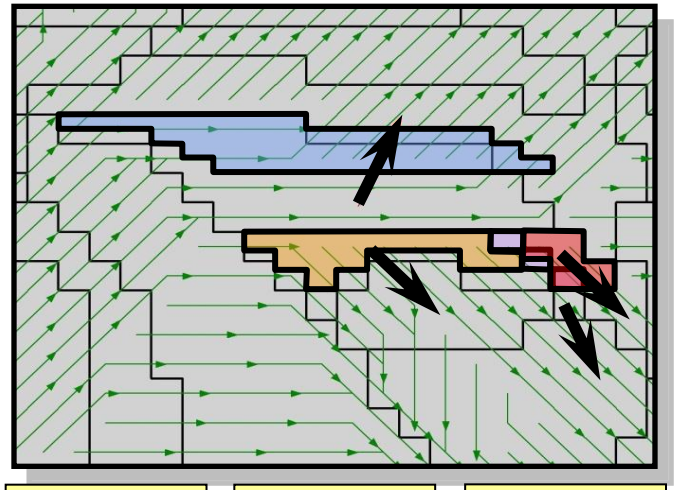
Integrated Landscape Management System (2/7)
J2000 Hydrological Model

- Quantitative hydrological model
  - Process-oriented
  - Conceptual
  - Fully distributed



- Objectives:
  - Water balance calculation in micro-, meso and macroscale catchments.
  - Spatially distributed representation of relevant water balance state variables and fluxes.
  - Temporal continuous simulation in hourly, daily or monthly time steps

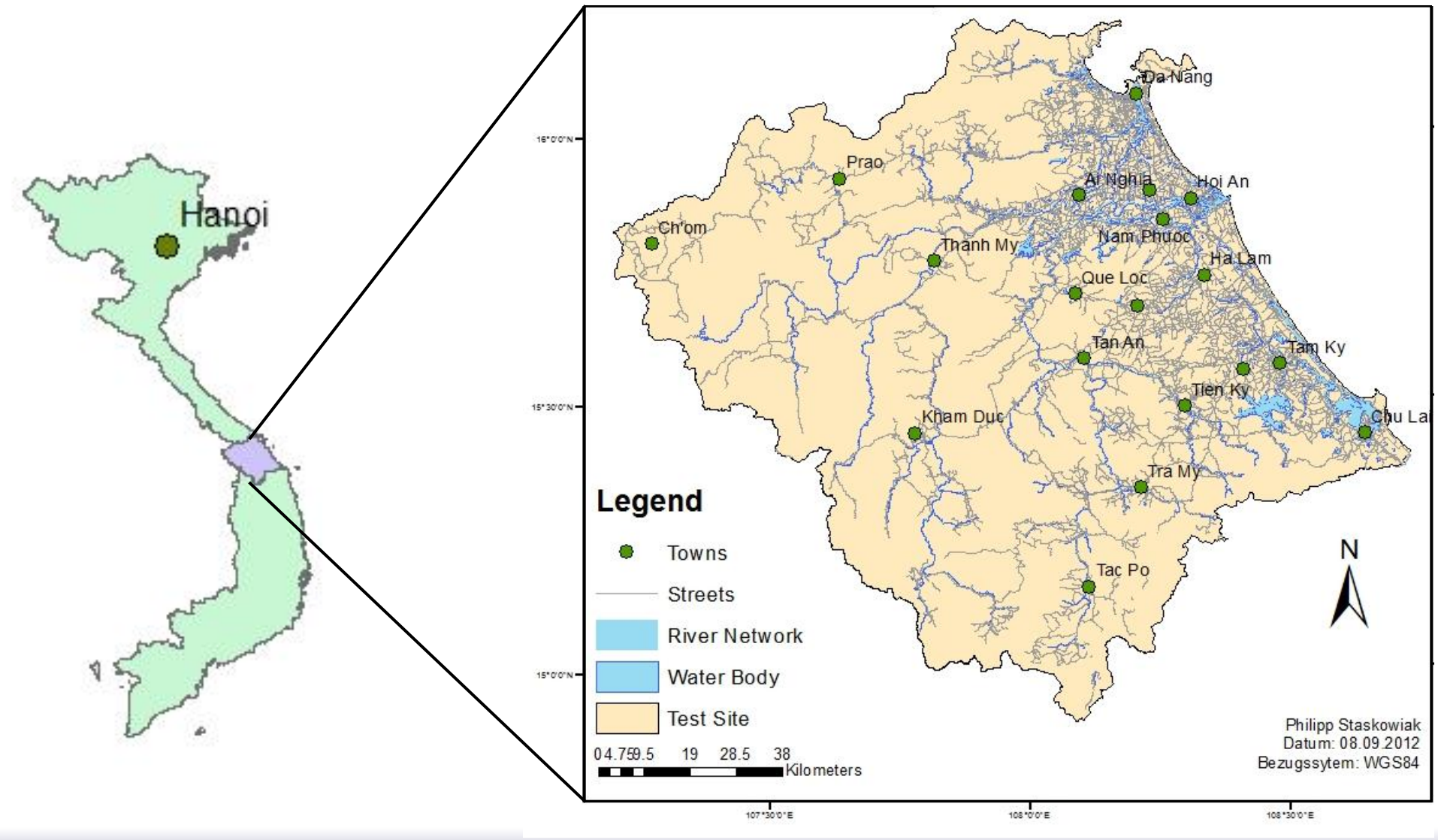
Integrated Landscape Management System (3/7)
J2000 Hydrological Model



HRU 1
HRU 2
HRU 3
HRU 4
HRU 5
HRU 6
Reach 1
Reach 2
Reach 3

Driving data: P, T, …
Additional drivers: Radiation …
ET
Interception
Snow
Unsaturated zone
Infiltration
DPS
MPS
LPS
MPS
LPS
MPS
LPS
Saturated zone
Upper zone
Lower zone
Runoff
Surface RO
Interflow 1
Interflow 2
Baseflow

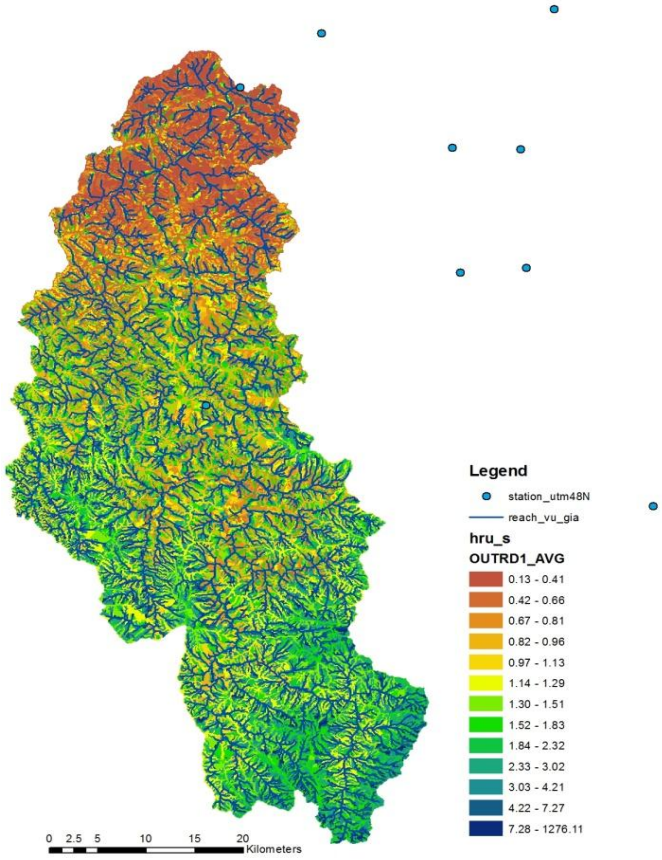
Integrated Landscape Management System (4/7)
J2000 HM, Vu Gia- Thu Bon River System (VGTB)



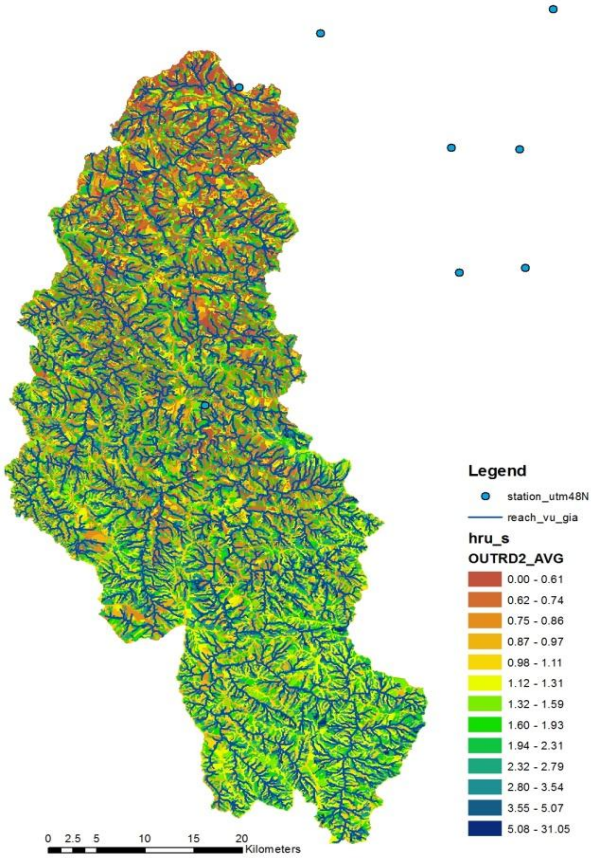
Integrated Landscape Management System (5/7)
J2000 Hydrological Model, Results VGTB

Runoff components (Vu Gia)

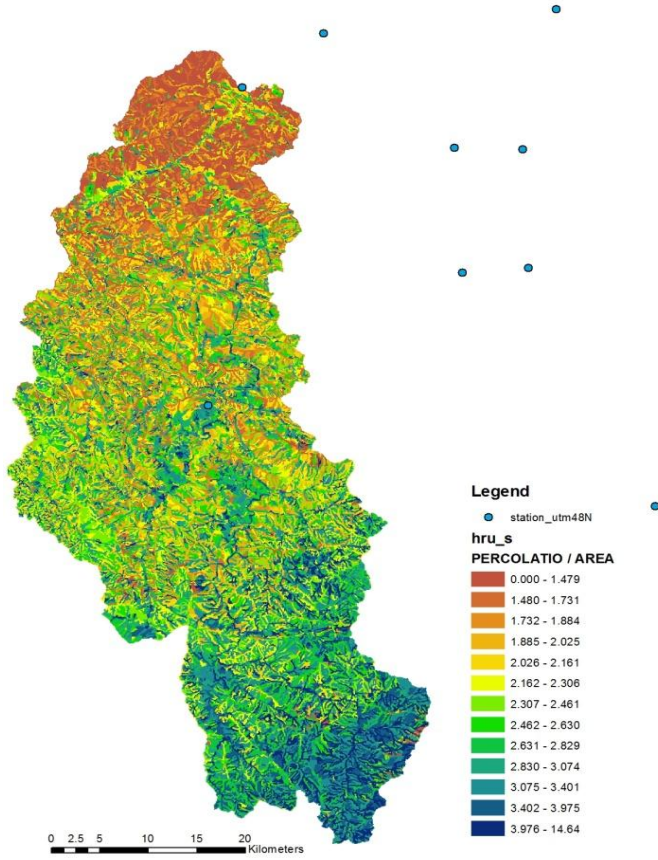
Surface Runoff



Interflow



Percolation

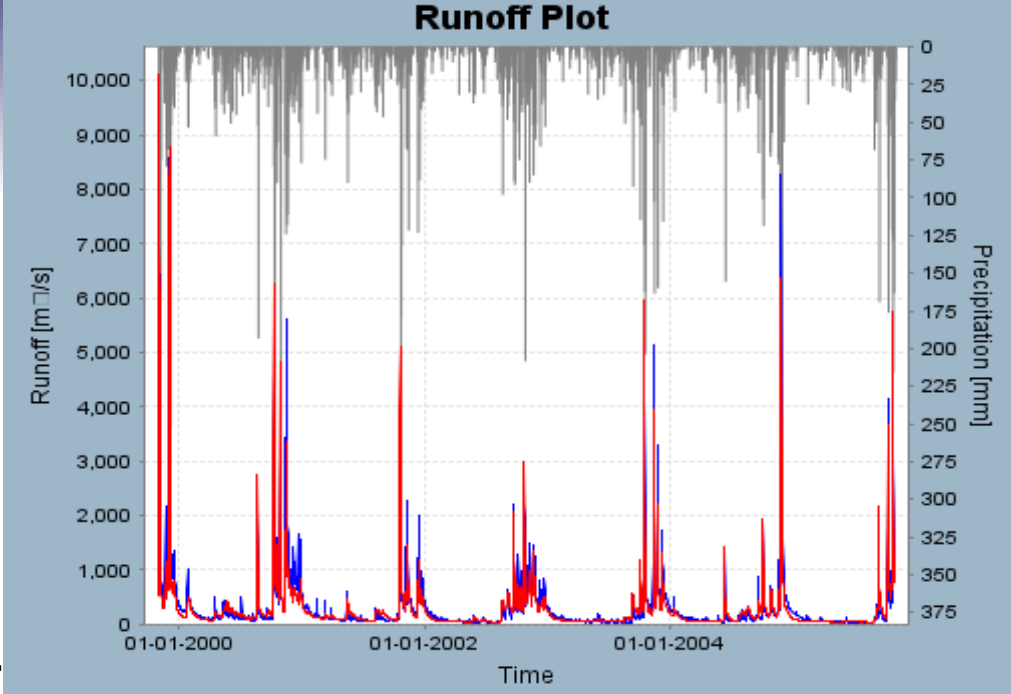


ILMS (6/7)
J2000 HM, Results VGTB

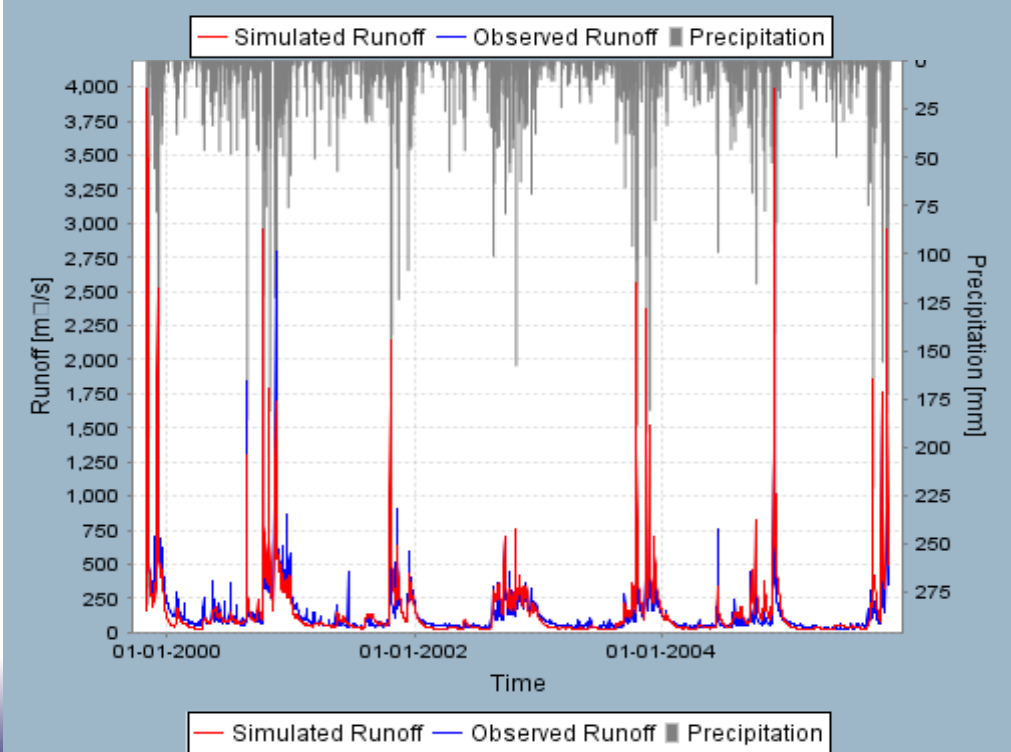
- Calibration Period:
  01.11.1996 – 31.10.2000
- Validation Period:
  01.11.2000 – 31.10.2005
- Results:
  Objective Functions

	Thu Bon		Vu Gia	
	Cal.	Val.	Cal.	Val.
e2	0.8647	0.8696	0.7696	0.6647
log e2	0.8501	0.8450	0.7619	0.6956
r^2	0.8683	0.8755	0.8364	0.8021
pbias	-12.83	-10.37	0.81	11.54

Thu Bon validation period



Vu Gia validation period



Integrated Landscape Management System (7/7)
J2000 Hydrological Model, Results VGTB

- The distributed J2000 model will be coupled with hydro-dynamic Mike 11 models for the lower reaches of the River System for
  - Flood modeling and
  - Salt water intrusion modeling
- The effects of hydrological infrastructure will be evaluated by coupling the J2000 model results with a Mike Basin model
- Scenarios for climate and land use change will be evaluated