Using SWAT and GETM to Model the Integrated Water Cycle within BASHYT

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The Context

Scientific portals are becoming more and more **key components** of many **large-scale Earth Science projects** and services world wide.

Through the integration of user-friendly web interfaces, researchers and scientists can **securely and transparently access to data, services**, **and computational infrastructures**, etc.

Public environmental agencies, stakeholders and citizens look ever more for such **centric gateways to applications based on workflow and dataflow services and a strong support in accessing to quality information**.

MOMAR and EnviroGRIDS

The FP VII **EnviroGRIDS** (http://www.envirogrids.net/) and the INTERREG **MOMAR** (http://www.mo-mar.net) projects, funded by the **EU aim at building observation and assessment systems for environmental changes** (climate, etc.) to support sustainable development.

The ambition is to develop **innovative ICT tools** for **monitoring the state of the environment** and improve transnational cooperation.

Our objective is to develop **a Collaborative Working Environment (CWE)** optimized for **data management,** spatial-temporal **analysis** and the **report production**, based on the models GETM (**G**eneral **E**stuarine **T**ransport **M**odel) and SWAT (**S**oil and **W**ater **A**ssessment **T**ool)

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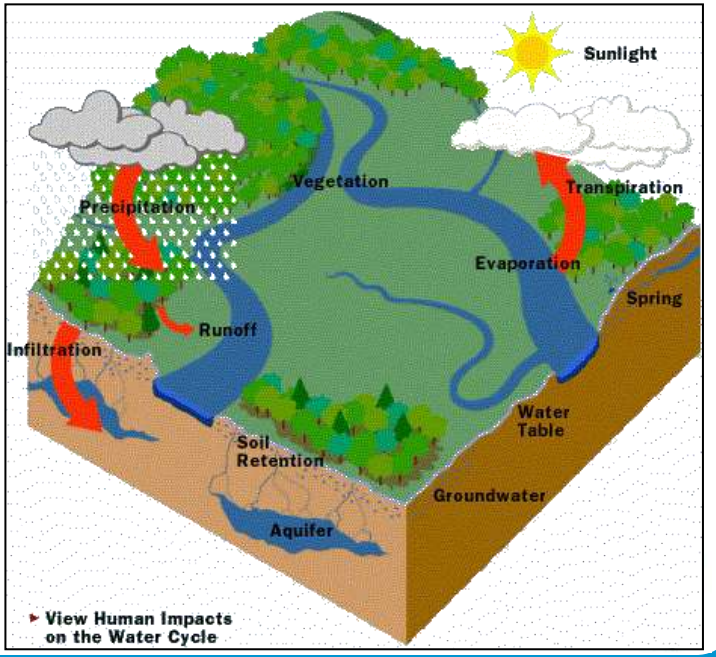
Soil and Water Assessment Tool (SWAT)

It is a **hydrological watershed-scale model** developed by the USDA Agricultural Research Service (ARS) and Texas A&M University.

SWAT aims at **predicting the impact of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds** with varying soils, land use, and management conditions over long periods of time.

The **water cycle** (precipitation, run off, infiltration, evapotranspiration, etc.), **sediment** cycle, **crop growth**, **nutrient** (**N, P**) cycle are directly modelled by SWAT.



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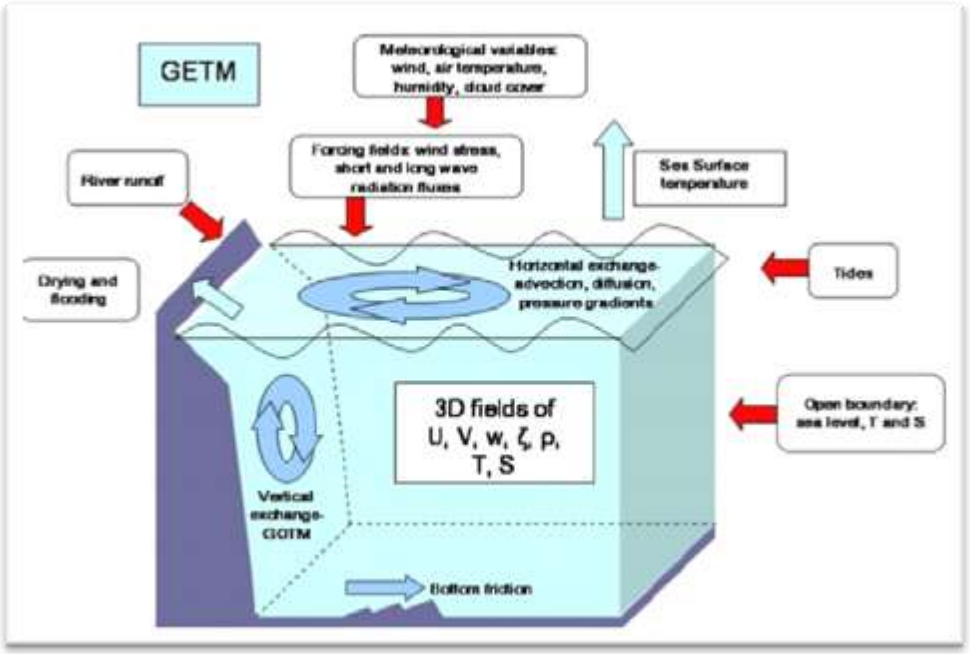
General Estuarine Transport Model (GETM)

GETM is a Public Domain, finite difference numerical 3D **oceanographic model**, most efficiently used to study shallow waters and natural processes in natural marine waters.

GETM simulates hydrodynamic and thermodynamic processes in natural waters, like **currents, sea level, temperature, salinity, and vertical / turbulent mixing**.



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The Collaborative Working Environment (CWE)

We aim at produce high resolution, local scale, models fed by meteorological and oceanographic regional operational models.

Our CWE environment is based on **BASHYT/ARGILLA**, a GIS self consistent development framework to design **WIS** (www.eraprogetti.com).

The CWE can be thought as an easy to use and extensible development framework for constructing spatially enabled web applications.

It exploits also the (Model–View–Controller (**MVC)** architectural pattern enabling for each component, independent development, testing and maintenance.

Our Approach

- Our approach is founded on centralizing all the model-related data (SWAT and GETM I/O) into complex Relational DB infrastructures.

- Shifting environmental application from the desktop oriented approach to the web based paradigm enhances flexibility in the whole system, extends the use of data and the sharing of experiences, fostering end user and citizen participation.

- The GRID/CLOUD layer is expected in the future to offer many advantages by which the management of computing and data storage resource, data and processing distribution, security, are just the most important.

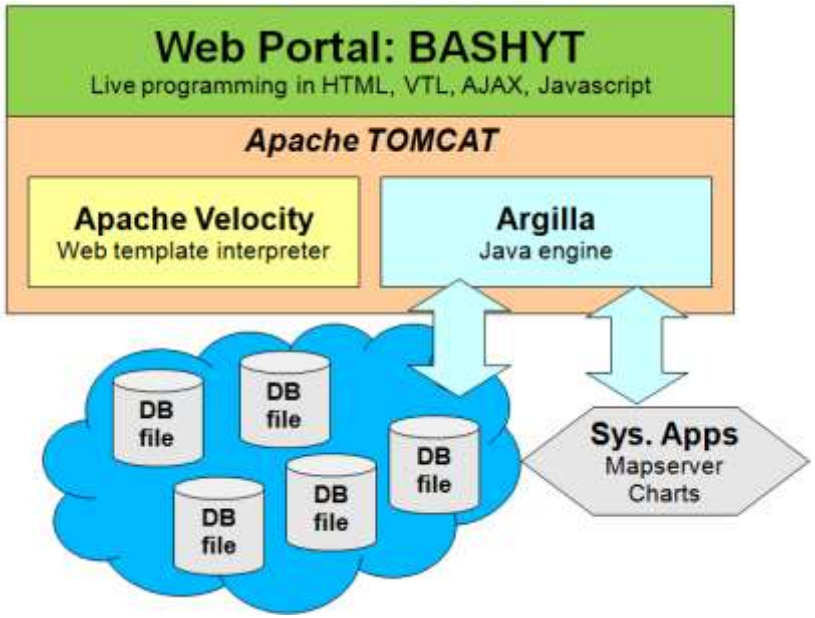
A distributed Geodatabase infrustructure

We have designed a new prototype of a scalable distributed geodatabase based on SpatiaLite (http://www.gaia-gis.it/) for large distributed data-intensive applications optimized for the GETM model.

Simulations are stored in Spatialite database files.

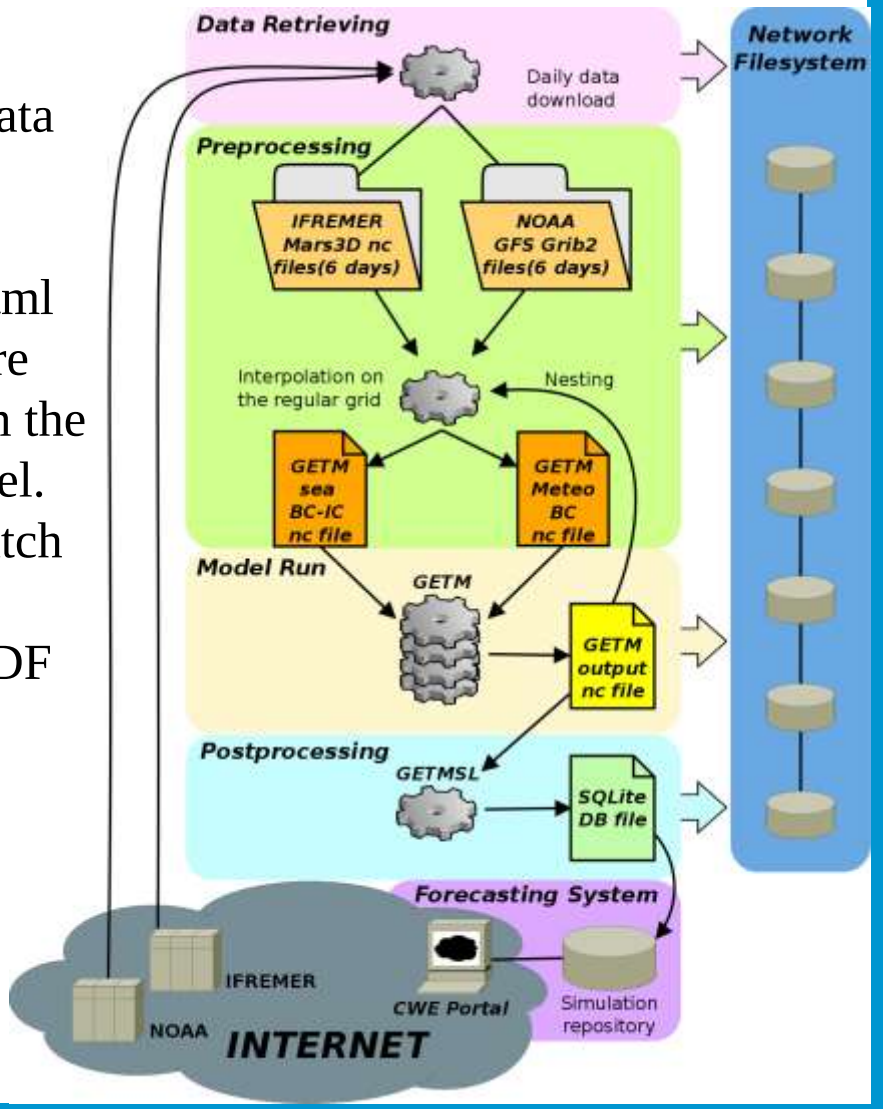
SQLite is an embedded database engine

This choice guarantees high performance accessibility to a large number of Simulations stored in a Distributed framework.



The GETM workflow

- a batch procedure downloads daily:
  - updated meteorological/oceanographic data from regional models:
    1. http://nomads.ncep.noaa.gov/
    2.http://www.ifremer.fr/thredds/catalog.html
- Boundary (BC) and Initial Condition (IC) are interpolated on the high resolution GRID from the above data for the GETM oceanographic model.
- a set of configuration files are updated to match each new operational condition;
- GETM is run and produce outputs in NETCDF format (about 4 GB).
- Each output file is processed to produce a spatialite db file to be displayed on the WEB interface .



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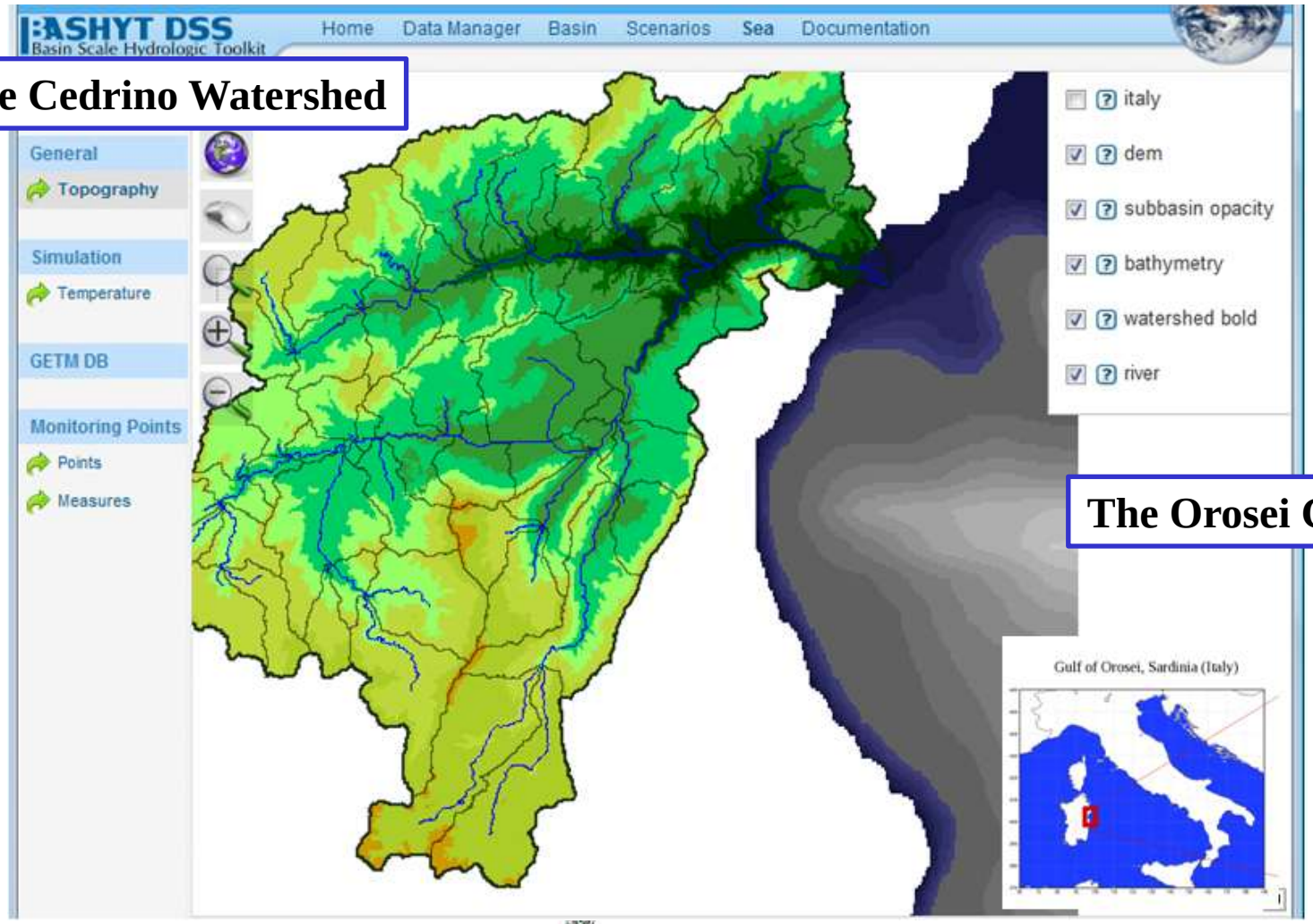

The Cedrino Watershed

The Orosei Gulf

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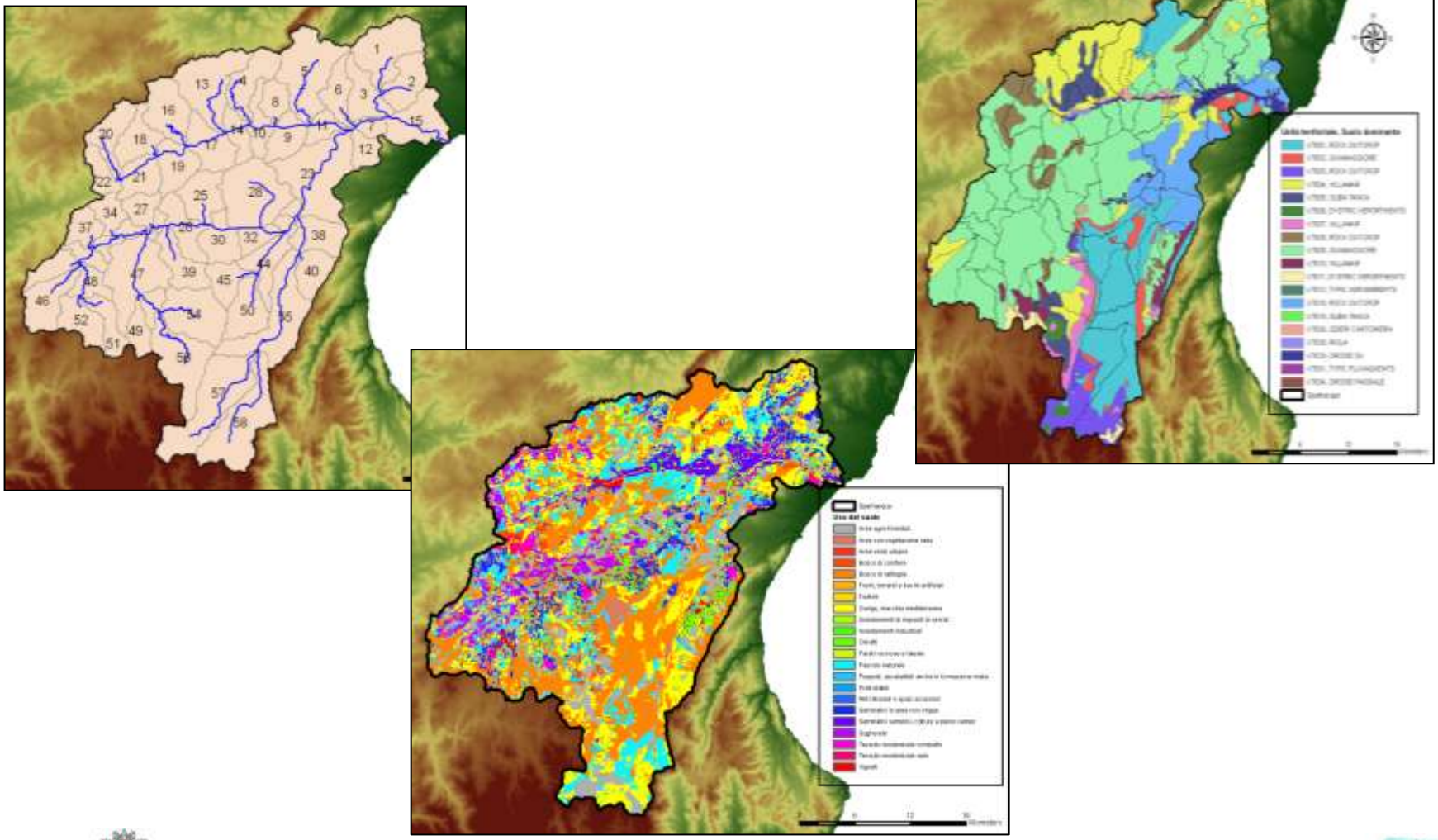
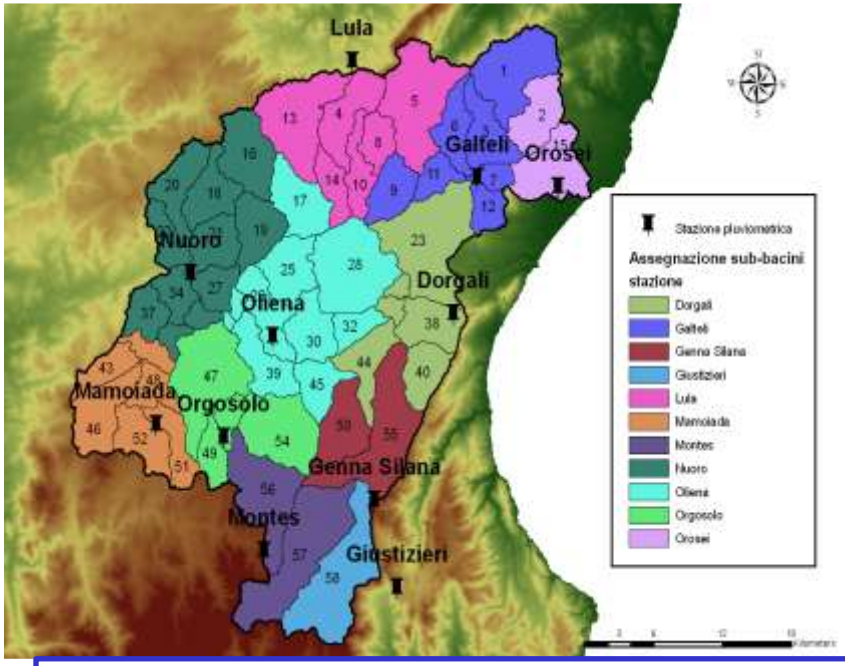
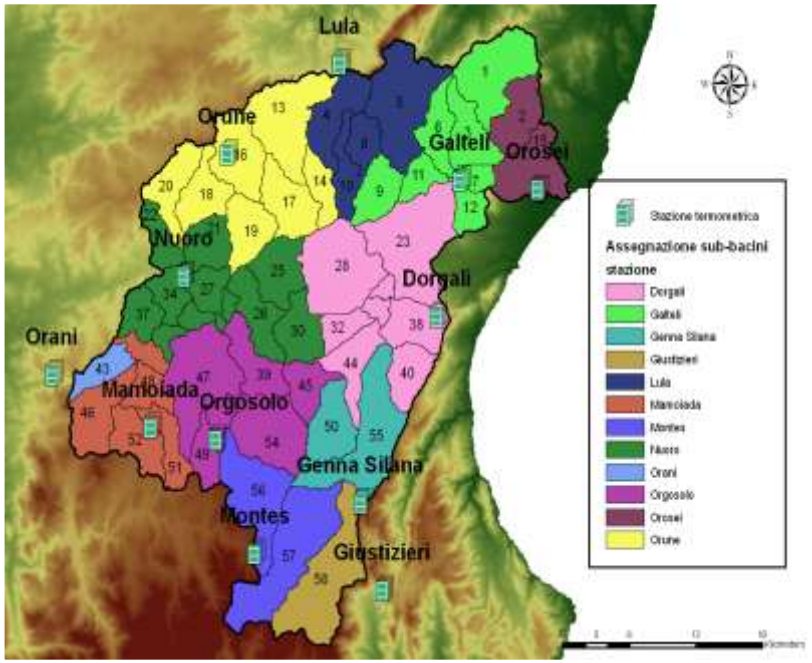




DAILY PLUVIOMETRIC DATA 1955-2007



DAILY TERMOMETRIC DATA 1955-2007

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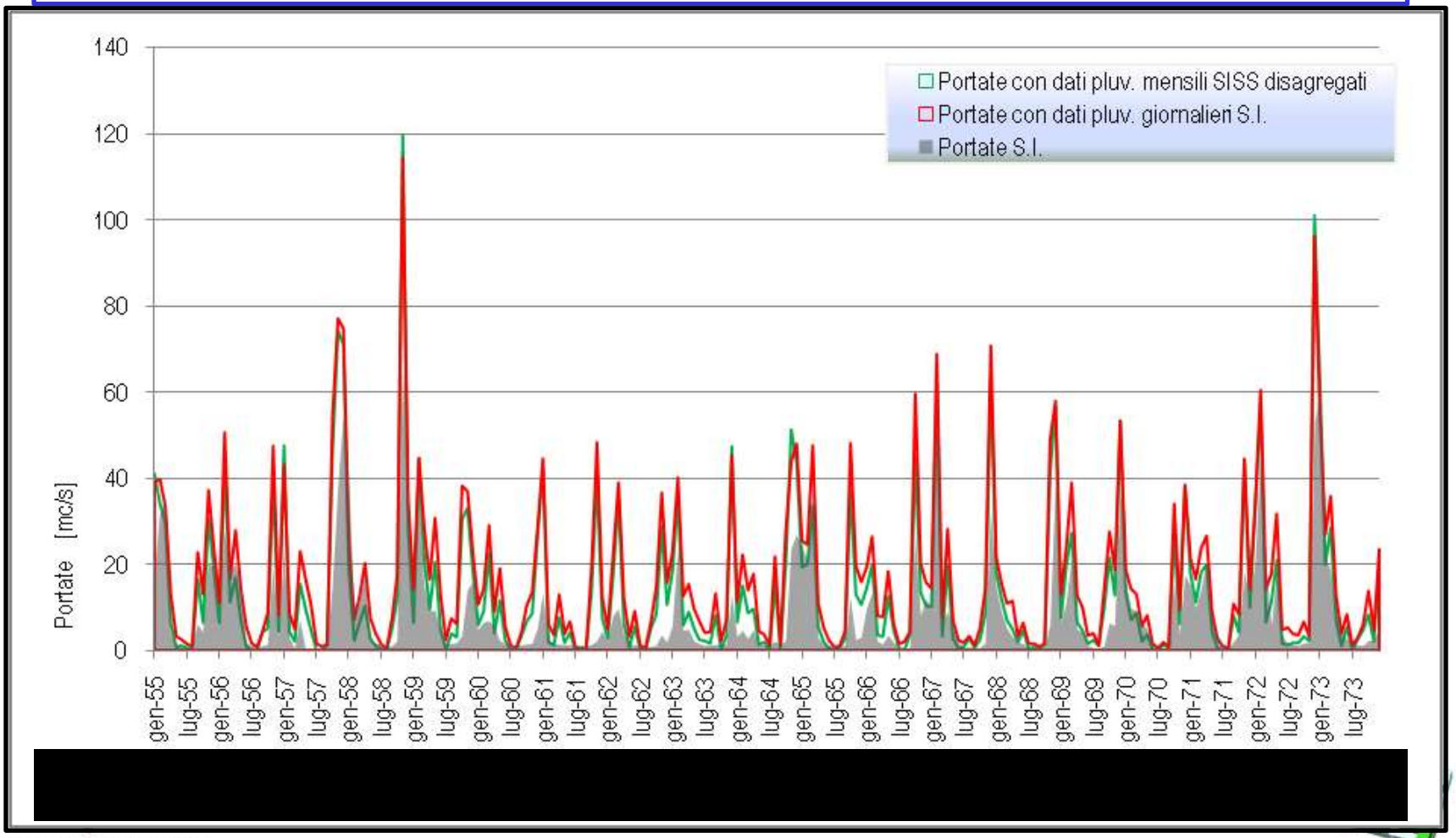
Simulation period 1955-1973

River Flow Gage: CEDRINO A PONTE CEDRINO 1955-1973

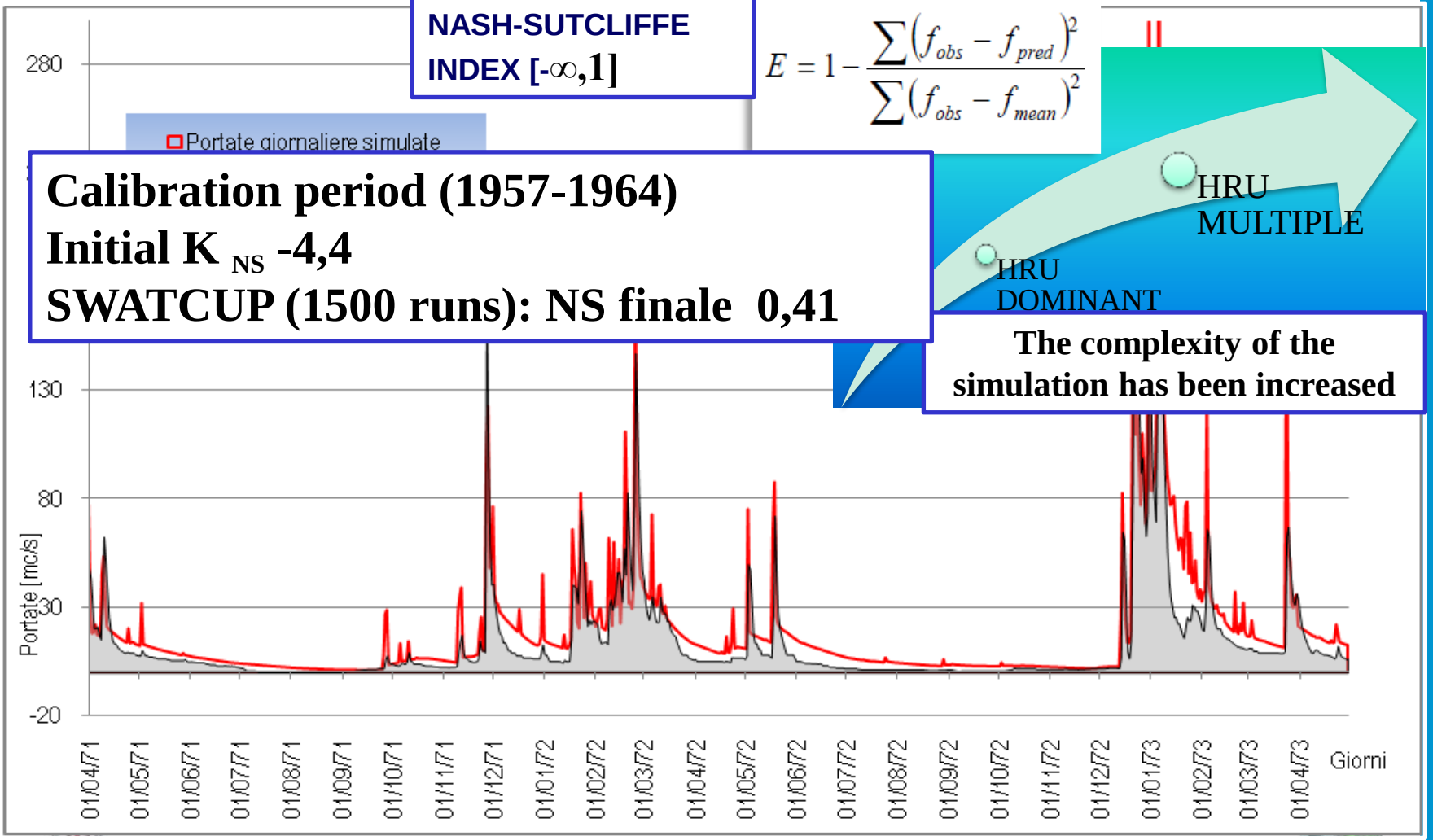


Calibration

NASH-SUTCLIFFE INDEX [-∞,1]

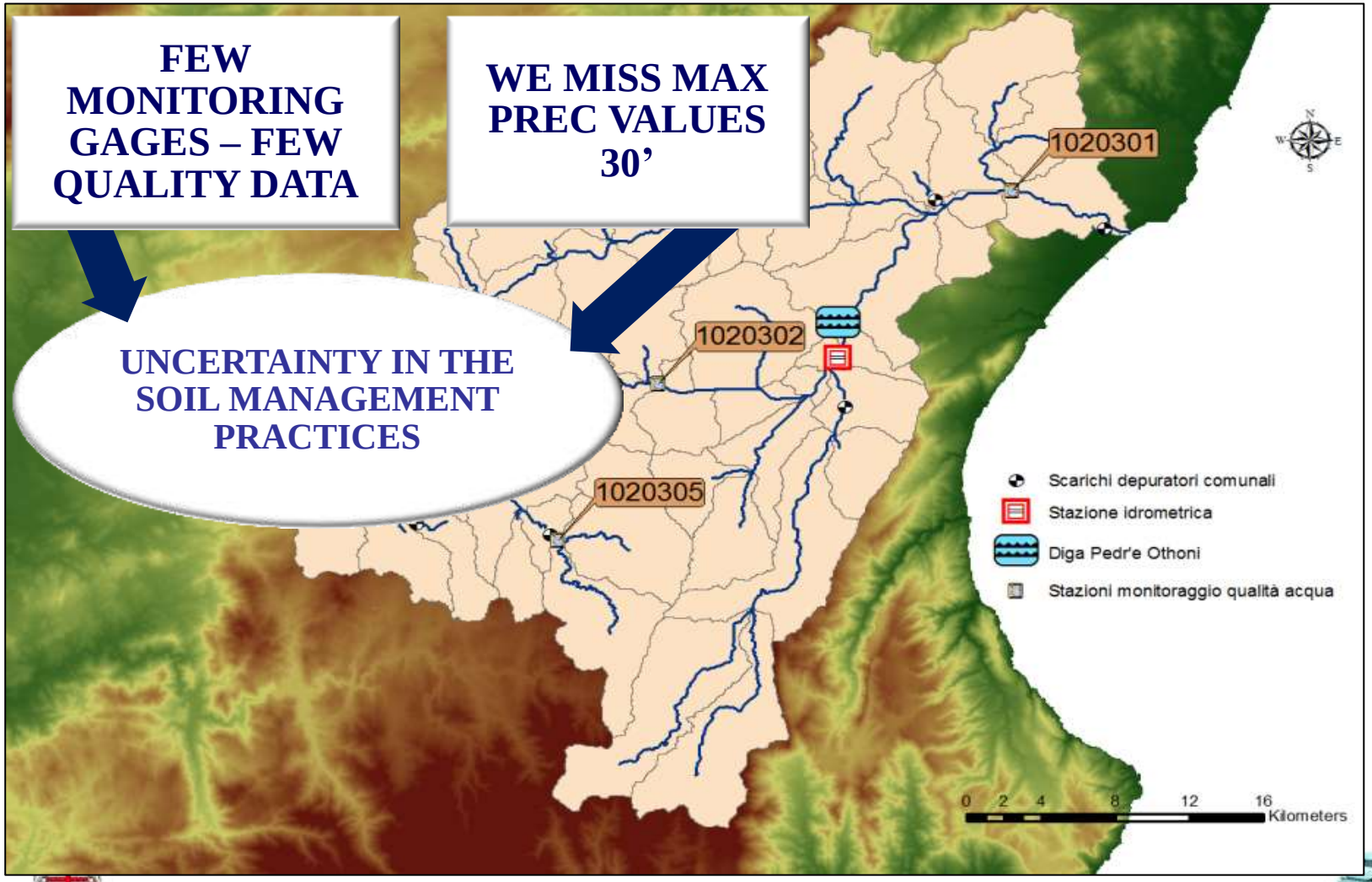
$$E = 1 - \frac{\sum (f_{obs} - f_{pred})^2}{\sum (f_{obs} - f_{mean})^2}$$

Calibration period (1957-1964)
Initial K_{NS} -4,4
SWATCUP (1500 runs): NS finale 0,41



The complexity of the simulation has been increased

Nutrients and sediment cycle

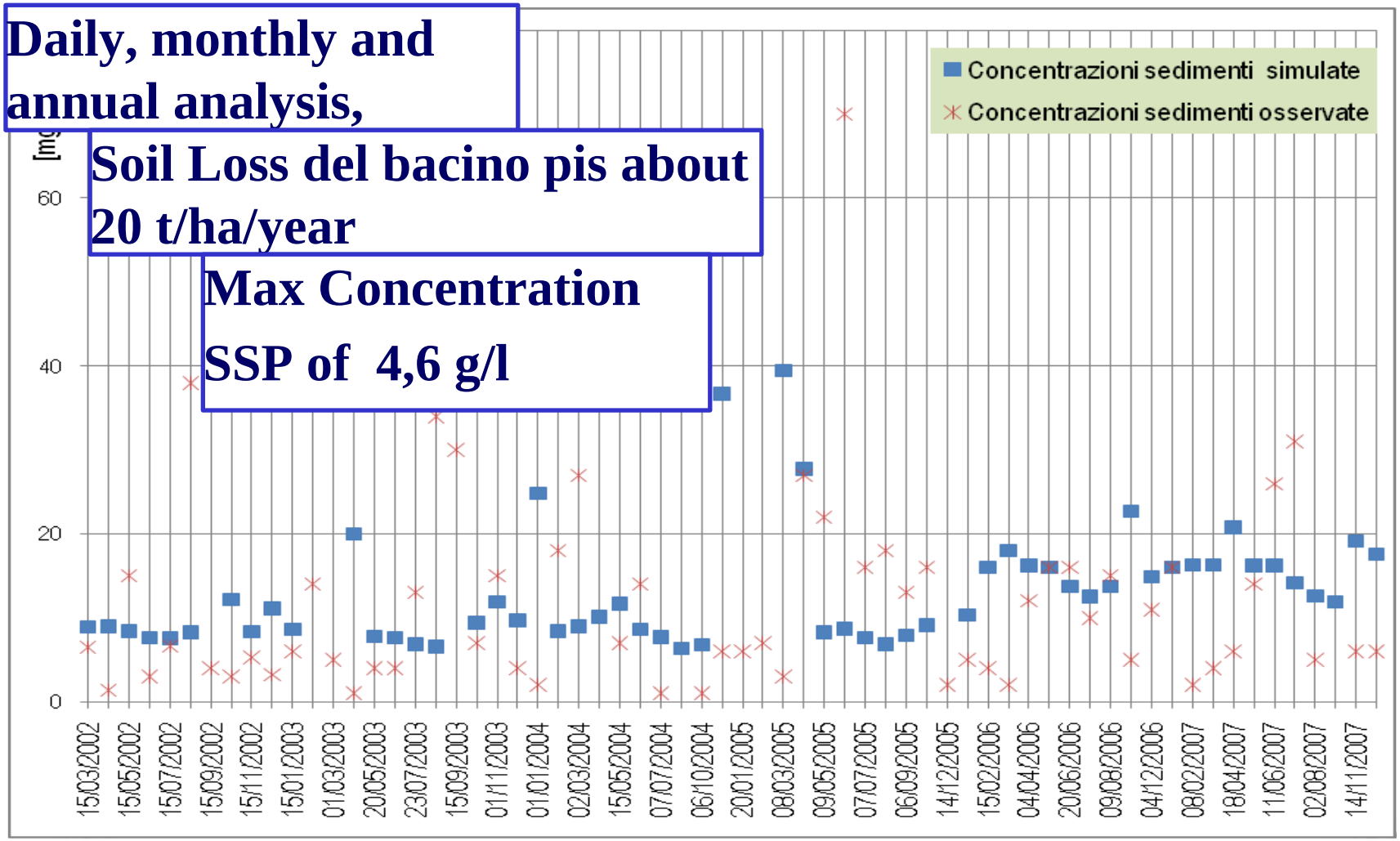


Sediment Cycle

Daily, monthly and annual analysis,

Soil Loss del bacino pis about 20 t/ha/year

Max Concentration SSP of 4,6 g/l



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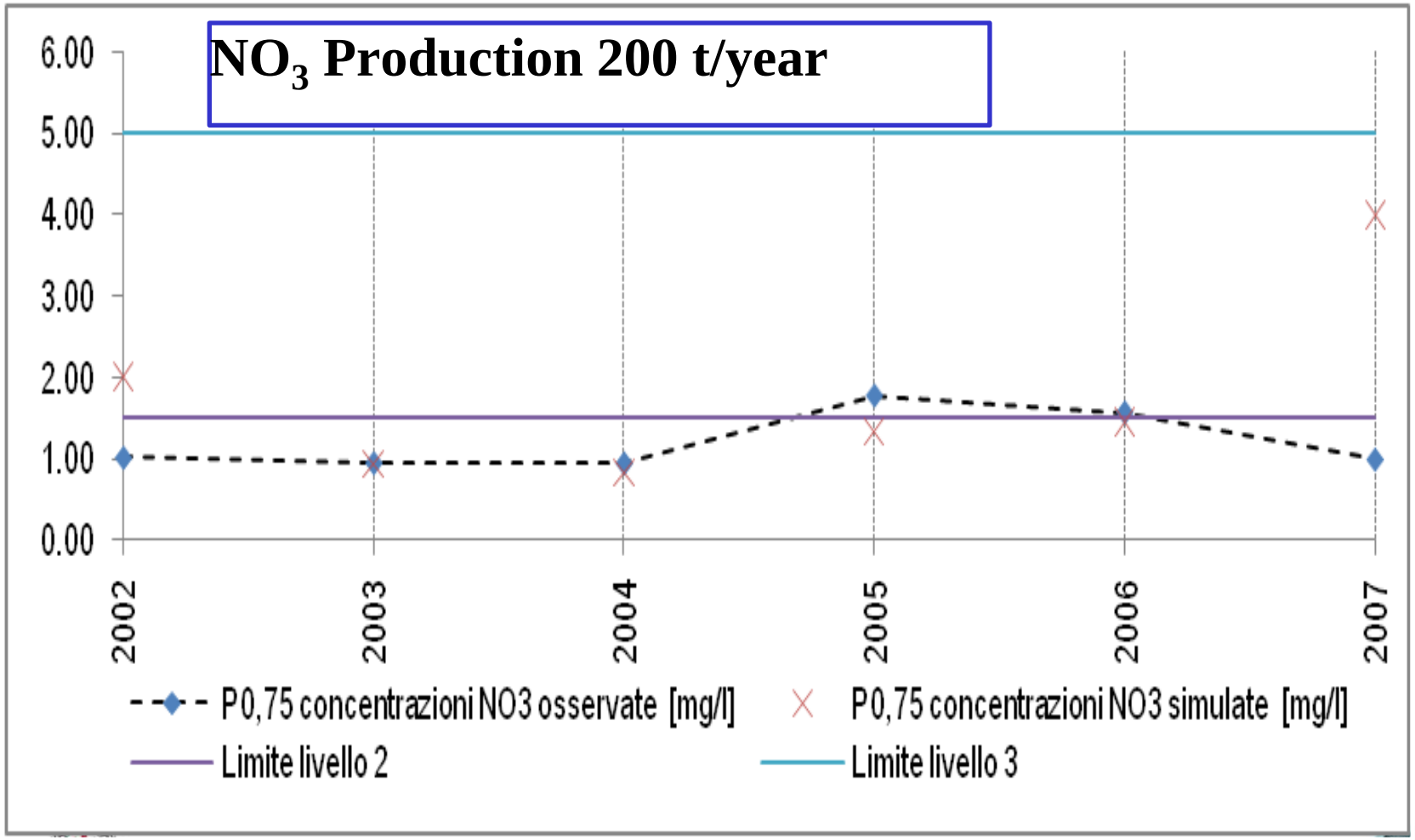
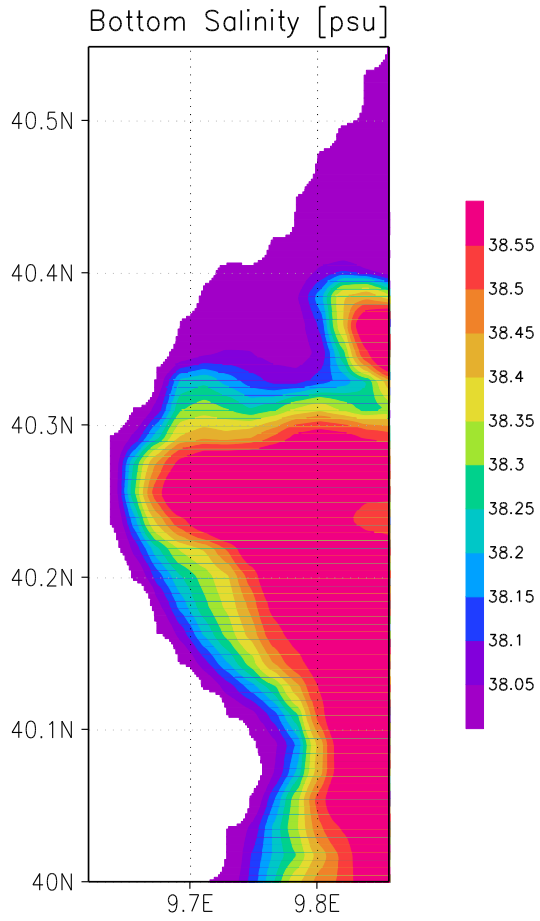
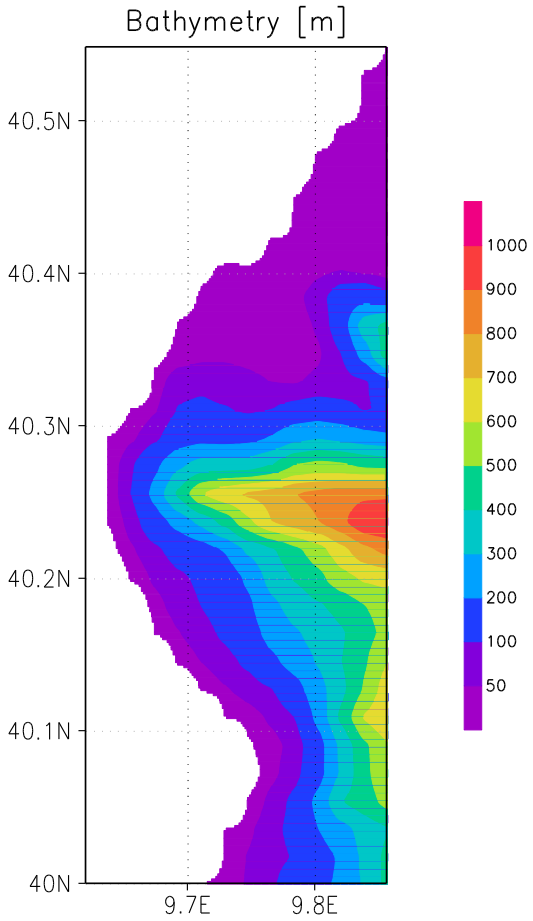
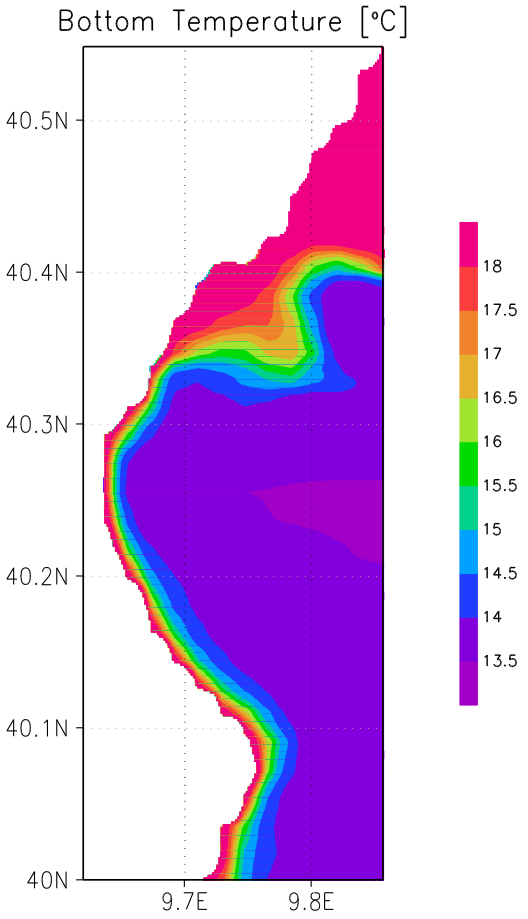
Nutrient Cycle



Integration of The SWAT model with the GETM







Estratta dal portale: http://www.moon-oceanforecasting.eu/

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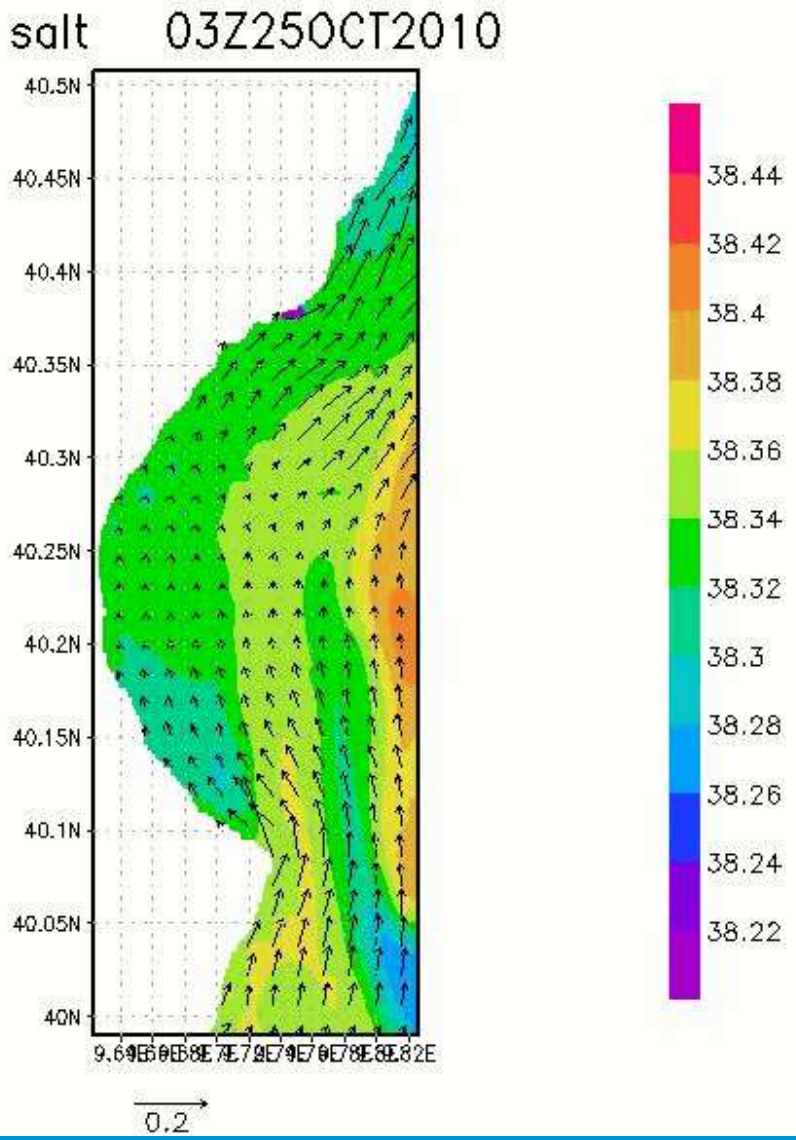
European Union

OROSEI GULF: River impact



Conclusions

The use of enlarged working **web based environments** is expected to increase data interpretation abilities at present exploited mainly with stand alone desktop applications.

Web applications, like ours, are **mostly data-driven**, with the reuse of information, model outputs, or simply territorial data from various Web data providers.

The use and integration of **advanced ICT technologies**, such as **GIS** or **numerical analysis tools** on the web is

- **complex** and involves major investments
- but offers high performance **computational and storage resources** providing new powerful means to analyze data.