# HYDROGEIOS, an integrated model for simulating complex hydrographic networks - A case study to West Thessaly region


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### *Topic 3: Meteorological, hydrological and geological risks, disaster management and mitigation strategies*



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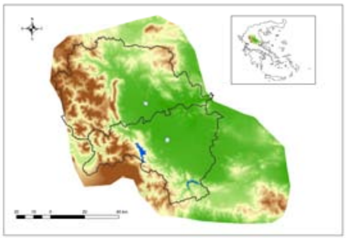
## Introduction

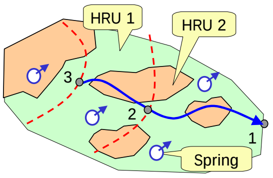
HYDROGEIOS is a physically-based scheme that integrates a conjunctive hydrological model and a systems-oriented management model, through a semi-distributed schematisation. It uses geographical, hydrological and water management data to reproduce the observed operation of a hydrosystem. Various modules are combined to represent the main processes at the water basin such as, soil moisture, groundwater, flood routing and water management. Simulated outputs include river discharges, spring flows, groundwater levels and water abstractions. The model is flexible considering both space and time scale. HYDROGEIOS was fitted to the West Thessaly region, using multi-response data for a 20-year period. Taking into account the complexity of the system under study, the adaptation of the model was very satisfactory, while useful conclusions were derived that may be used for management purposes.

## The Western Thessaly hydrosystem

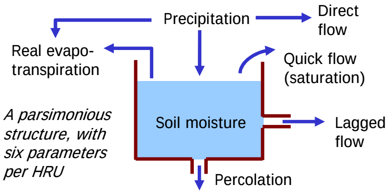


- Watershed area of 6087.5 km$^2$, lying on three prefectures.
- A main river branch (Penios) and five important tributaries.
- Extended irrigated areas supplied by both surface and groundwater resources, as well as by water diverted from the neighbouring Plastiras reservoir.
- Relatively poor infrastructures.
- Many authorities, with different interests, involved in water management.

## Surface hydrology processes



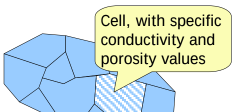

A physically-based approach is implemented, by assigning model parameters on the basis of the physical characteristics of the watershed. This is ensured through the use of hydrological response units (HRUs), which are spatial components that correspond to areas with homogenous hydrological characteristics.




*A parsimonious structure, with six parameters per HRU*

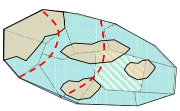
The surface hydrosystem comprises the river network and the sub-basins upstream each node. For each sub-basin and HRU combination, a conceptual **soil moisture accounting model** runs to compute the transformation of precipitation to real evapotranspiration, deep percolation and flood runoff; the latter, together with the estimated spring runoff (baseflow) is directly transferred to the downstream node of the corresponding basin.

## Groundwater hydrology processes

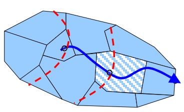



*Groundwater cell layer*

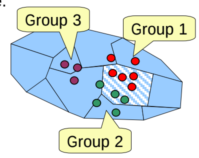
A Darcian multi-cell scheme is established, based on a non-rectangular discretisation of the groundwater system. Each cell is represented as a conceptual tank, of which the stress components are: (a) **percolation** from each sub-basin and HRU combination, (b) **infiltration** losses from each river segment, and (c) **pumping** from each borehole.



*Union of cell, sub-basin and HRU layers*

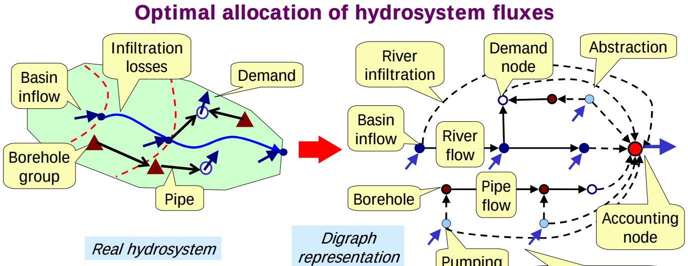


*Intersection of cell and river network layers*




*Intersection of cell and borehole layers*

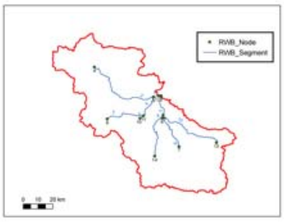
## Optimal allocation of hydrosystem fluxes



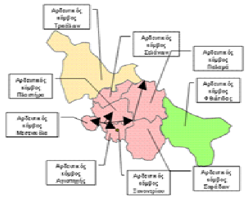

- surface and groundwater (spring) runoff, assumed point supply
- groundwater yield (= pumping capacity)
- water needs, constraints and priorities
- real capacities and unit cost values of hydrosystem components

Calculation of all **hydrosystem fluxes**, by transforming real components to digraph components, assigning virtual inflows, unit costs and capacities, and solving a linear programming problem

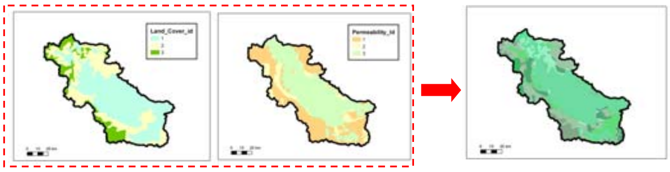
## Input data and schematisation




*The river network consist 13 nodes, 12 river segments and 12 sub-basins*



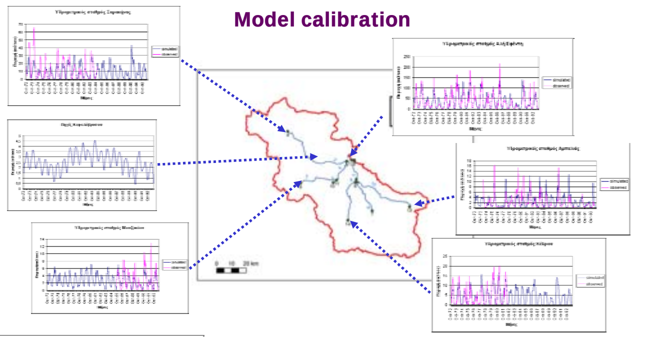
*Layout of the irrigation network; the water needs were estimated on the basis of cultivated areas*

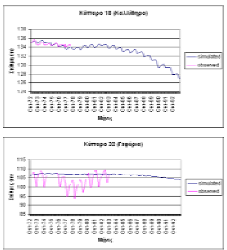



*Nine hydrological response units were produced, as the union of land cover and permeability layers; three categories of each feature were combined (irrigated areas, low vegetation and forests for the former, low, medium and high permeability for the latter)*

*48 groundwater cells (right figure) were formulated, on the basis of the average piezometric map (left figure); two of them are virtual, representing springs. Water table observations were available for 11 cells.*

## Model calibration





Model parameters (100 in total) were estimated through a hybrid calibration strategy, based on both manual and automatic methods. A multicriteria objective function was formulated comprised of:

- the determination coefficients and the bias (mean error) of five hydrographs;
- the bias of the average spring flow;
- the determination coefficients of the water table series (representing the flow regime of the corresponding cells);
- an error measure for the rest of groundwater cells, to avoid undesirable water level trends.

## Conclusions - Proposals

- The model fitting is satisfactory, taking into account the complexity of the hydrological processes, the simplifications regarding the hydrosystem operation, and the various errors contained in the observed data used in calibration.
- The optimised parameters are consistent with the physical characteristics of the basin.
- The schematisation procedure was driven by the calibration, regarding some critical features of the hydrosystem, such as the management of floods.
- The study helped to understand the hydrosystem operation, providing a reliable estimation about the main hydrological processes as well as the real allocation of water abstractions.
- The results may be used as the basis of an integrated water management plan for the study area, whereas the model can be extended as a planning and assessment tool for new hydraulic projects and management practices.

## Acknowledgments – Contact info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Project web page: http://www.odysseusproject.gr/

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