Multi-reservoir management with OpenMI

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Aim of this study

- To study the operation of two reservoirs supplying an area, taking into account the reservoir's interaction with the catchment and monitoring its operation in real time.
- To evaluate the optimization capabilities of OpenMI in real scenarios and applications

The scenario under study

The Smokovo reservoir is used to cover a number of demands in the surrounding area.

The case study in this project is to evaluate the usage of an additional reservoir, that is Lake Xyniada, to cover the needs in the Smokovo area, while maintaining its own operational needs as well as the irrigation needs it is covering already.

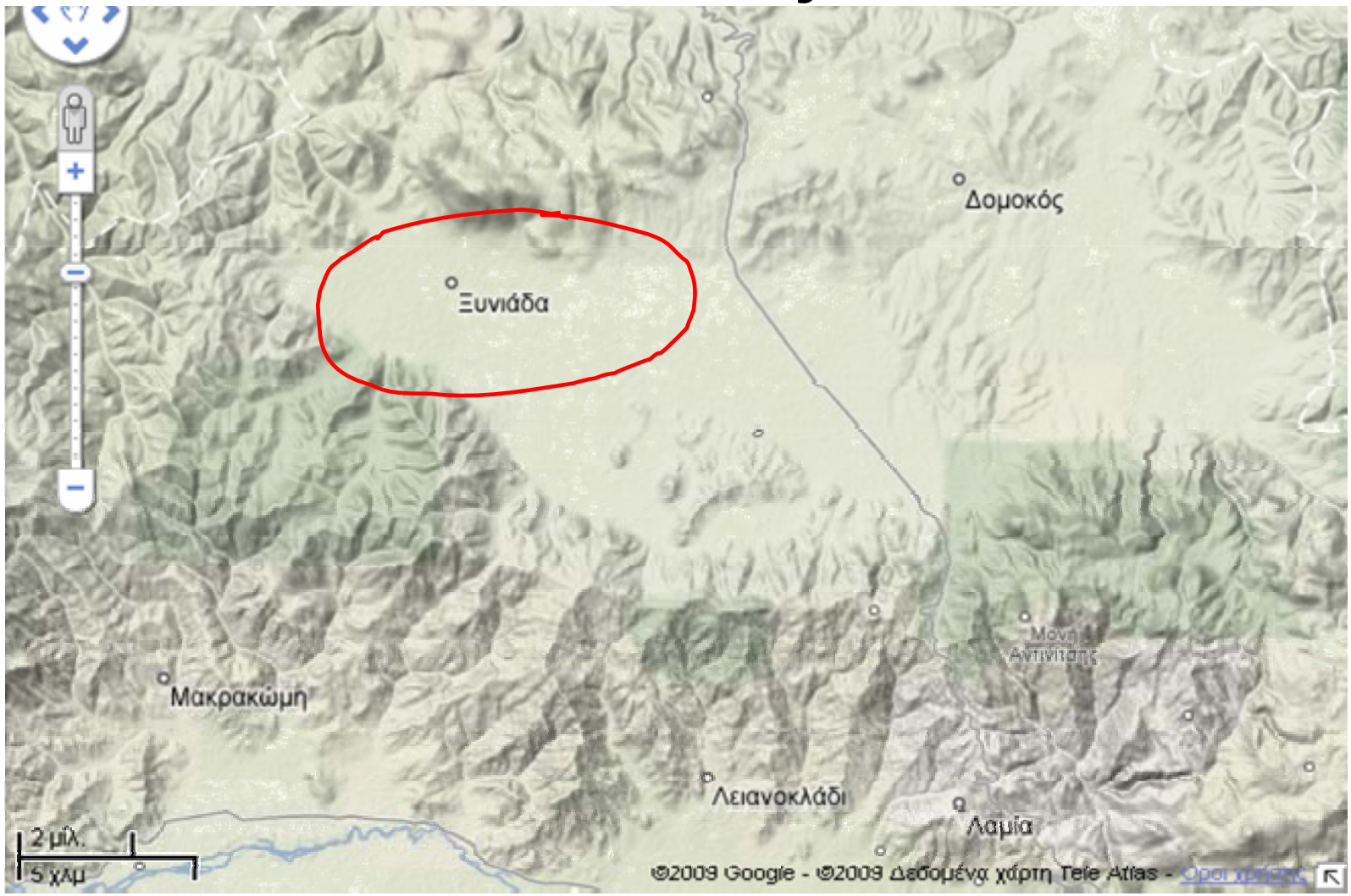
The two reservoirs are connected with an open channel and an additional hydrological model from Mike11 is connected through openMI to simulate the rainfall-runoff in the catchments in question.

The scenario under study

The two reservoirs exchange data through a rule component, which calculates the total volume and defines the water in each reservoir.

The Smokovo Reservoir

The area around Lake Xyniada



Study area in Xyniada

The area where Lake Xyniada used to be, is now dried up and a valley stretches over it. The water that should have been there is collected and used solely for the agricultural needs of the area.

Part of the planned scenario is that Lake Xyniada may be recreated, and while supplying the Smokovo reservoir, it should still be able to cover the existing agricultural needs, and water for environmental purposes.

Scenario set up

Reservoirs are represented with the model RMM-NTUA.

The catchment rainfall and runoff properties are represented with DHI Mike11/NAM module.

A rule component is implemented to perform the calculation of the total volume in the two reservoirs.

All models are linked in openMI.

Input Data

- Time step and time horizon of simulation
- Level-storage and level-surface data (given as point-series)
- Characteristic levels (minimum, maximum, initial)
- Upstream watershed area
- Time series of precipitation and evaporation depths
- Leakage function coefficients (monthly)
- Water uses properties (priority order, demand time series, operational rules)

Smokovo and Xyniada reservoir properties

	Smokovo	Xyniada
Minimum Level	+285m	+450.5m
Intake Level	+331m	+451m
Spill level	+375m	+454m
Dead Storage	28.4hm^3	10.7hm^3
Total capacity	237.6hm^3	42.9hm^3
Useful storage	209.3hm^3	32.2hm^3
Maximum area	8.4km^2	31.6km^2
Upstream watershed area	260km^2	100km^2

Water uses

Demands covered by the Smokovo reservoir

- Environmental preservation
- Water supply
- Irrigation

The reservoir in Xyniada is covering solely the agricultural needs of the area, and with the planned scenario, supplies the Smokovo reservoir with additional water to cover its ever- growing needs. Additionally Xyniada, needs to maintain some water for environmental reasons.

Operational rules for target needs

- Water release for environmental preservation, 10 hm^3 /y
- Abstractions through Leontari tunnel for water supply, 15 hm^3 /y
- Abstractions through Leontari tunnel for irrigation, 150 hm^3 /y
- Additional water release for irrigation, 20 hm^3 /y

Operational rules for target needs

Management of main irrigation for Smokovo reservoir

Three reservoir level zones are assumed <340m, 340 – 350m and >350m, with corresponding rates of allowable water release 0, 50 and 100%

Management of secondary irrigation for Smokovo reservoir

Four reservoir level zones are assumed <340m, 340 – 350m, 450-360m and >360m, with corresponding rates of allowable water release 0, 40, 80 and 100%

Operational rules for reservoir balance

A rule is applied for the total volume and its allocation in each reservoir defining whether the reservoirs may release water or not. Water released from Xyniada, is sent as outflow to Smokovo reservoir.

Total Volume	Smokovo	Xyniada	Total Volume	Smokovo	Xyniada	Total Volume	Smokovo	Xyniad
0	0	0	110	90	20	210	170	40
10	5	5	120	100	20	220	180	40
20	10	10	130	110	20	230	190	40
30	20	10	140	120	20	240	200	40
40	30	10	150	130	20	250	210	40
50	40	10	160	140	20	260	220	40
60	40	20	170	150	20	270	230	40
70	50	20	180	150	30	280	240	40
80	60	20	190	160	30	290	250	40
90	70	20	200	160	40	300	260	40
100	80	20						

Input time series rainfall and evaporation

Simulation period: July 2002 – December 2005

Simulation time step: 1 day

Hydrological inputs:

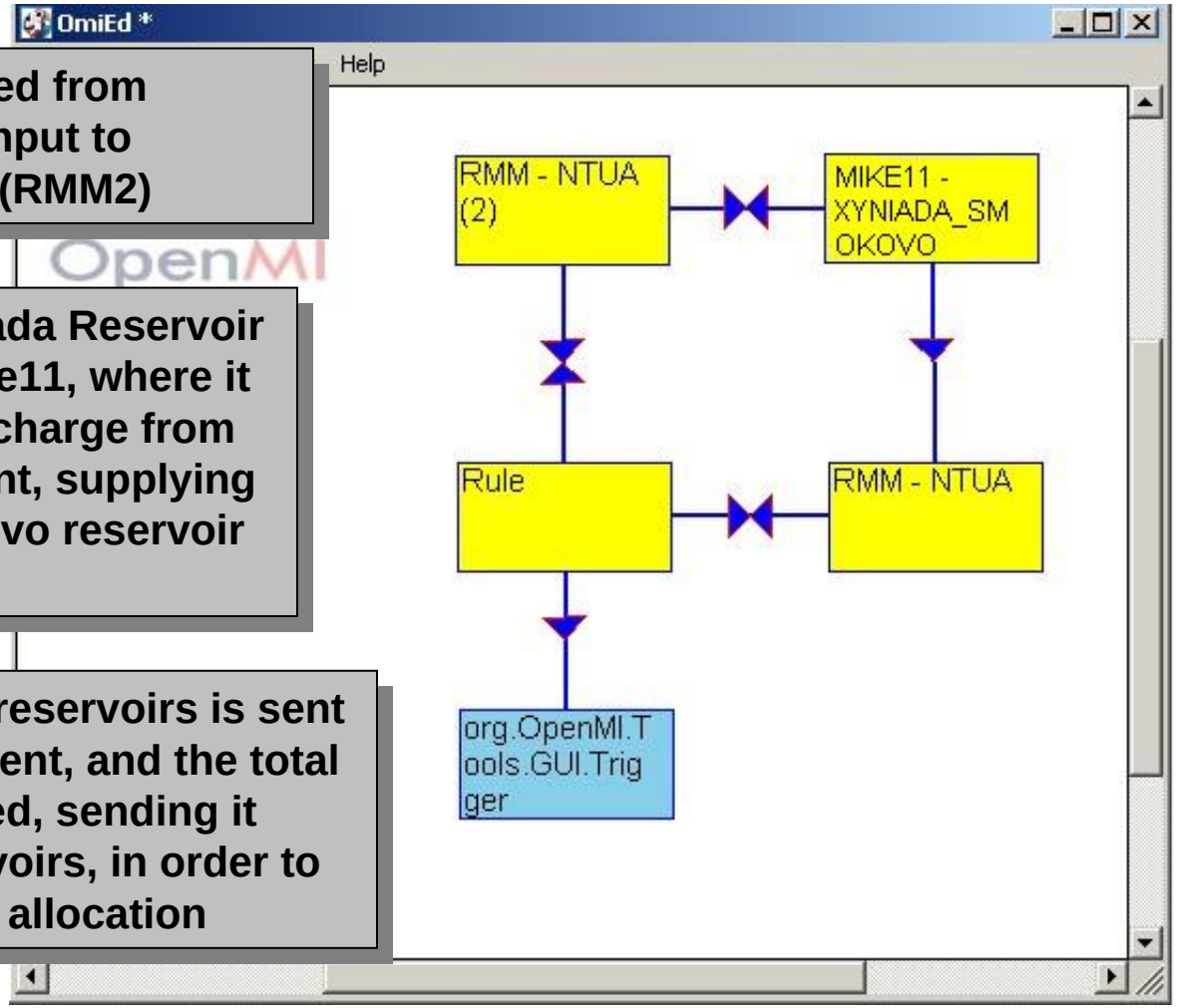
- Inflow time series from the upstream watershed, provided by Mike11/ NAI after calibration
- Rainfall depths from nearby stations
- Evaporation depths, estimated on mean monthly basis and uniformly disaggregated

The scenario represented in the OpenMI Editor

Discharge calculated from Mike11 is sent as input to Xyniada Reservoir (RMM2)

Outflow from Xyniada Reservoir is sent back to Mike11, where it is added to the discharge from Smokovo catchment, supplying the input to Smokovo reservoir (RMM)

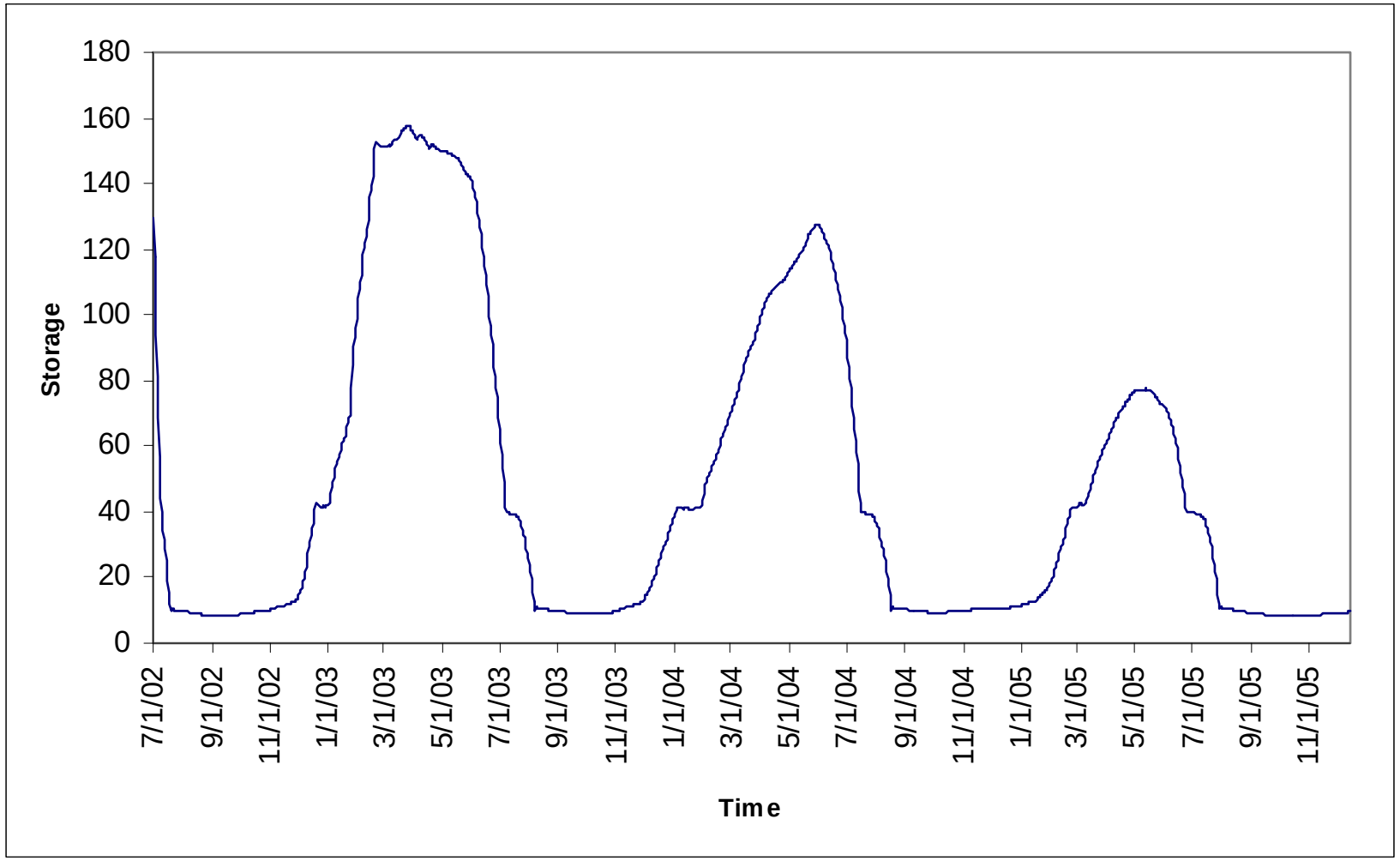
Volume in the two reservoirs is sent to the rule component, and the total volume is calculated, sending it back to both reservoirs, in order to correct the volume allocation



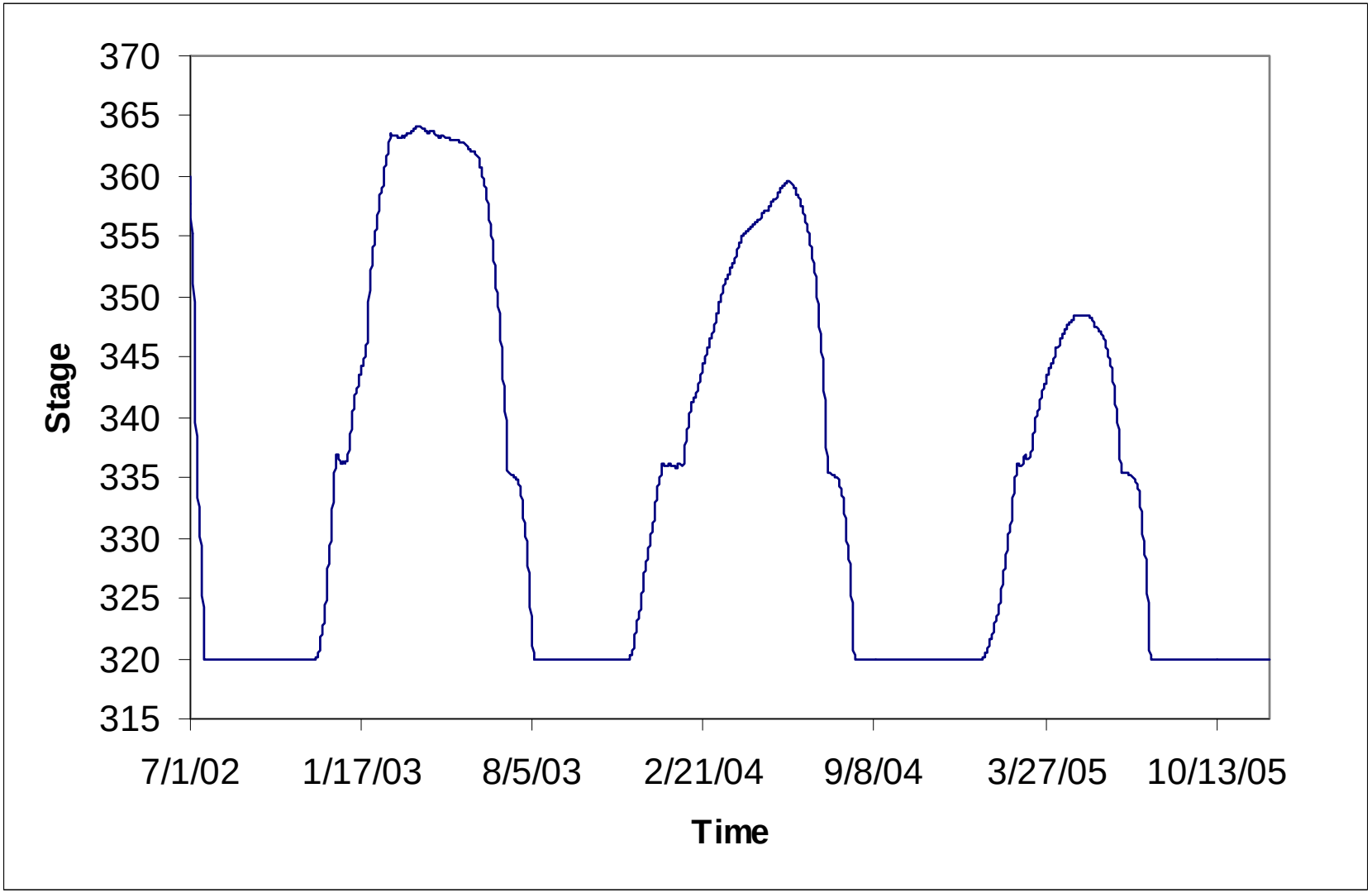
Output files and results

The linked scenario is successful and both reservoirs allocate the water for their demands. Output files are created for storage, stage, and spill if any, as well as water sent for individual needs in both reservoirs.

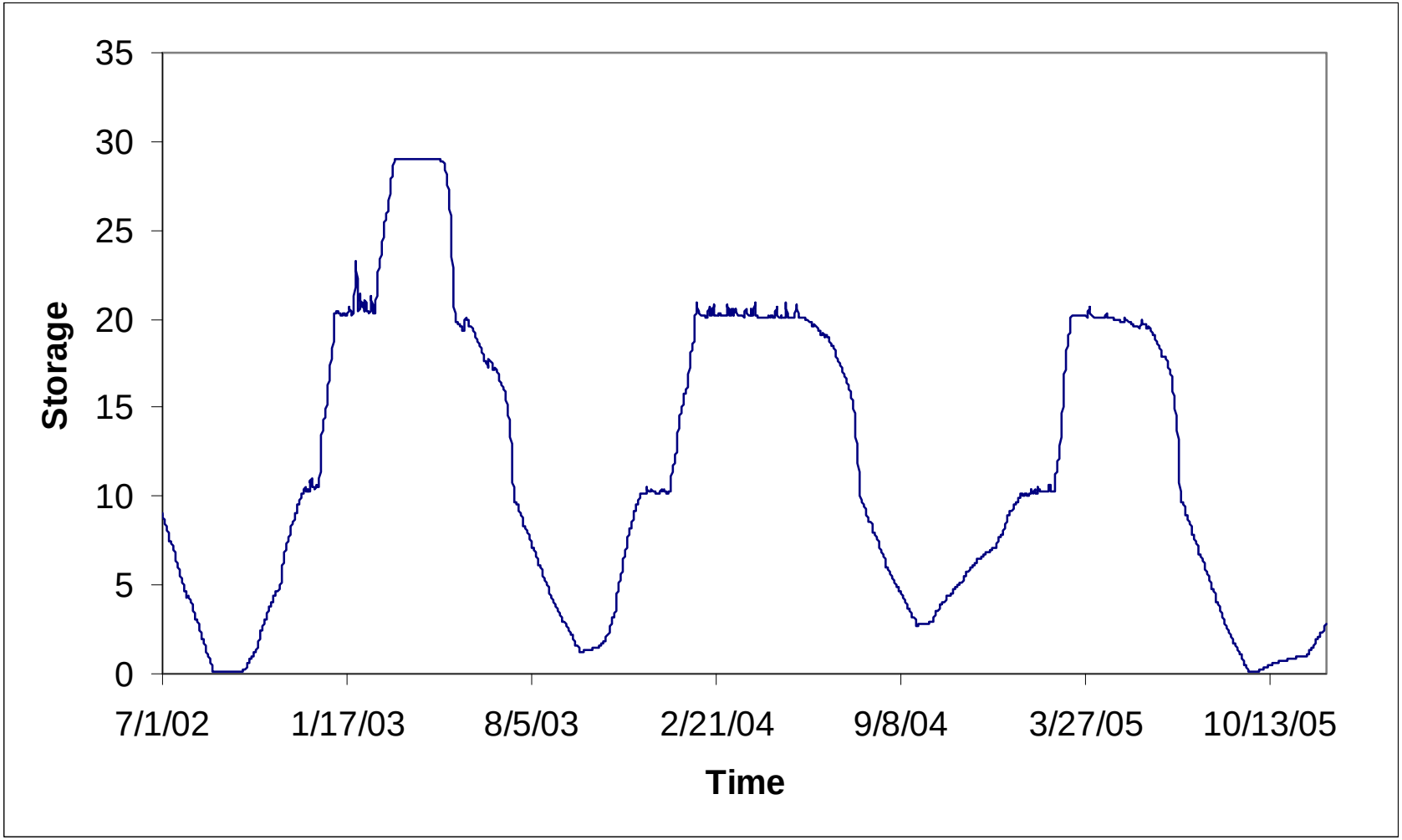
Smokovo - Reservoir operation



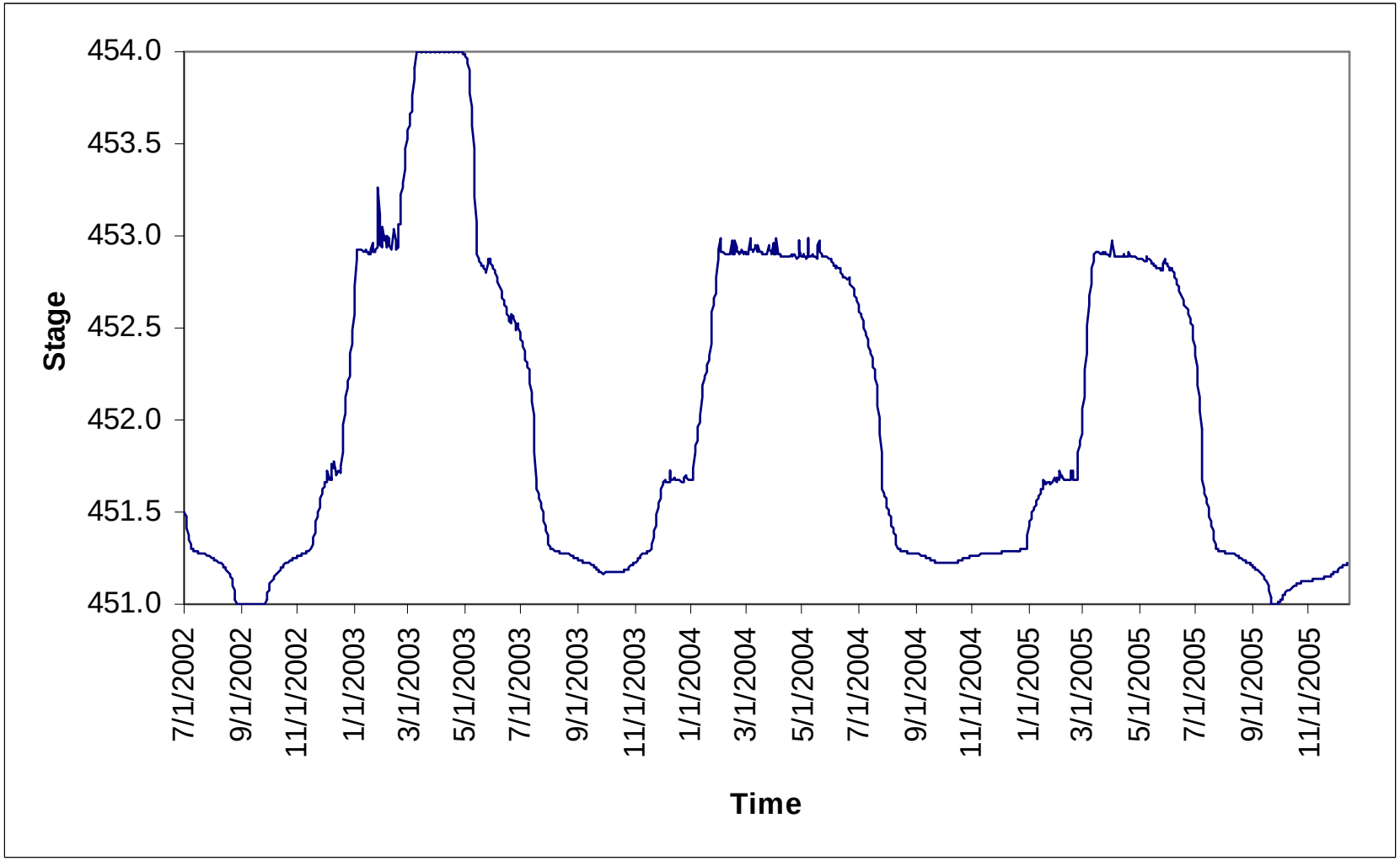
Smokovo – Reservoir stage



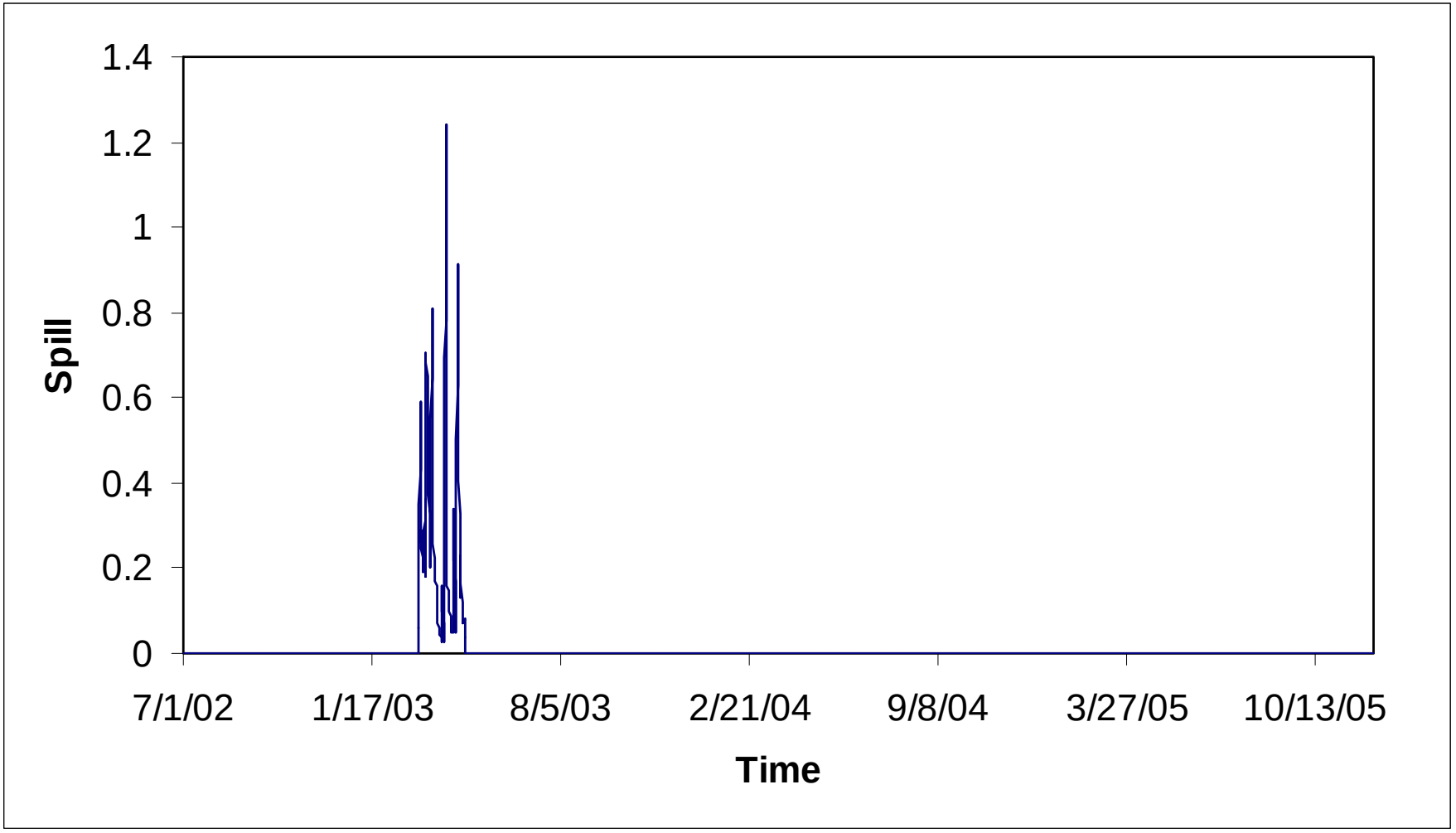
Xyniada - Reservoir operation



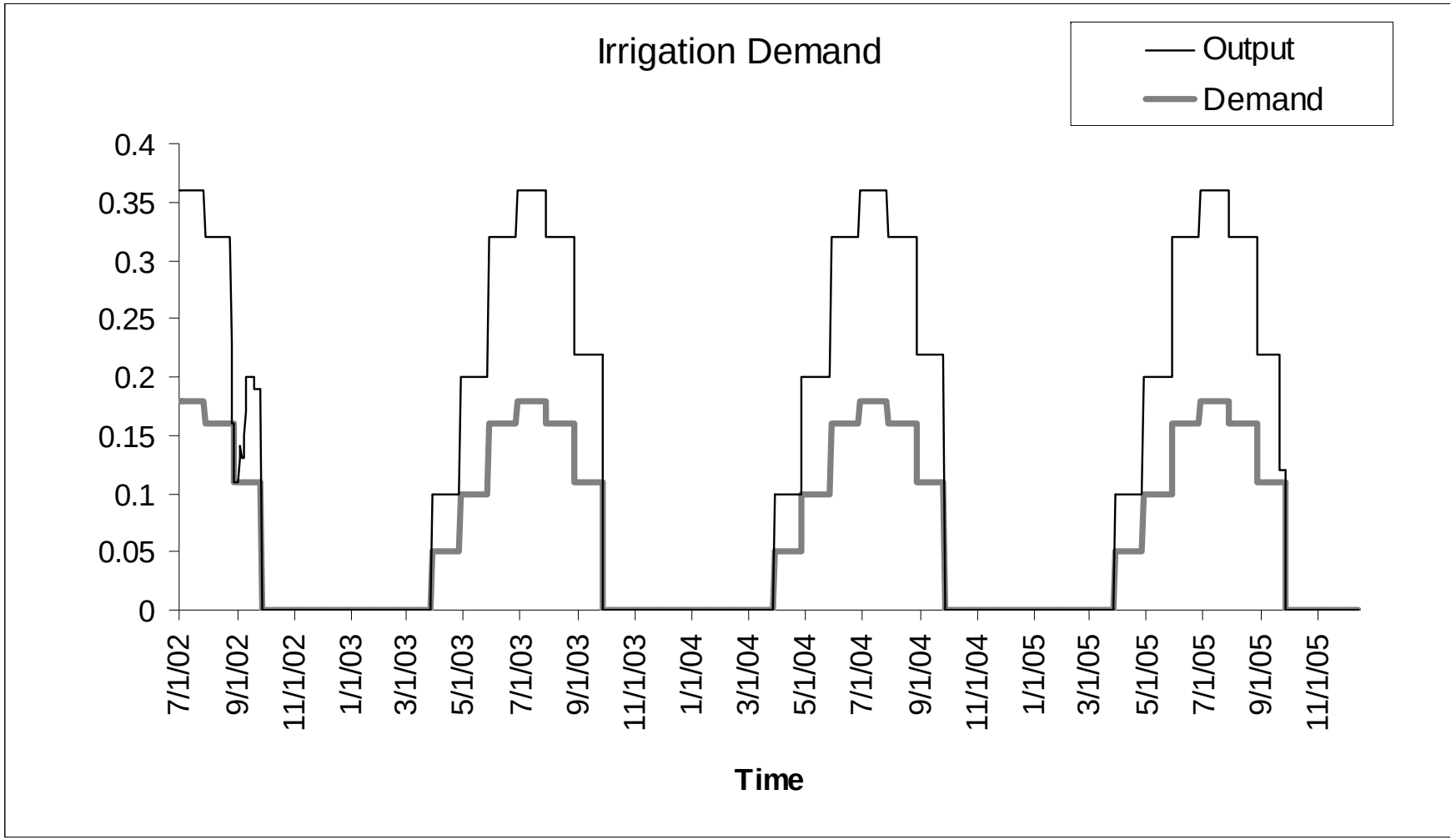
Xyniada - Reservoir stage



Xyniada - Reservoir Spill



Demands and Outputs



Design Parameters

Mike11

Rainfall time series, Boundary conditions, watershed information, channel cross-sections, etc.

RMM-NTUA

Reservoir design

Demands, priority and allocation rules

Rule component

Allocation of volume according to the total volume

Evaluation

- The models run and exchange data in real time.
- A multiple reservoir system may be set up and monitored taking into account the interaction with the water basin, the reservoir balance and needs and demands.
- The rule component, allows a possible optimization tool to assist in design and decision making in water management.
- The set up of such a scenario through openMI saves substantial time, by the real time exchange of data, instead o running the models consecutively and separately.

Future Work

- Provide different design parameters to test the scenario unde different circumstances
- Provide different rules for water allocation in each reservoir, according to the demands and reservoir operation
- Further the scenario by adding new models, such as an additional reservoir, or an economical optimization model.
- Through this application a possible restoration of Lake Xyniad may be designed, used both as an additional reservoir for the supply of Smokovo, as well as covering its own needs, and providing additional uses, to the surrounding area.

References

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http://www.openmi.org/

http://www.openmi-life.org/

Thank You for your attention!