InterFlood 3: Innovations in Flood Mitigation, Management & Resilience

Polyline QW-approach in river forecasting system with minimum requirements

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MapMakers LLC

MapMakers is a leading russian company for **environmental forecasting** and **hydrometeorological sofware** developement:

- developing high quality software for gathering, processing and visualisation of meteoinformation
- hydro-meteorological services market leader from 1994
- GIS METEO technology is the framework of Roshydromet territorial subdivisions
- owns the weather-informational portal GISMETEO.RU with several millions a day traffic

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Setting up the Problem

- Availability of hydrological and morphometry data still remains a vital problem
- Atmospheric models, such as GFS, ECMWF or modelling complexes, such as WRF, are widely used for forecasting needs
- Increasing computer resources make numerical atmospheric forecasting easier

SOLUTION

Simple semi-distributed hydrological model, based on high resolution meteorological fields data as inputs, which doesn't need for field data to launch the simulation and is simply tuned.

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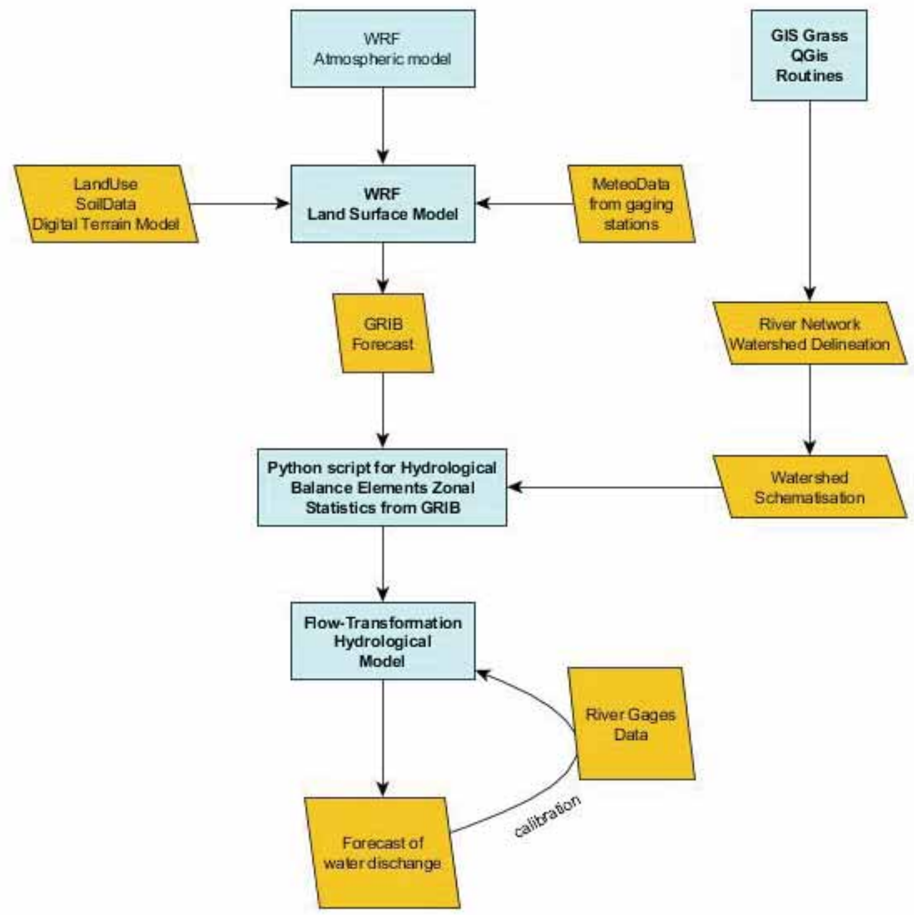
The scheme of Data Processing



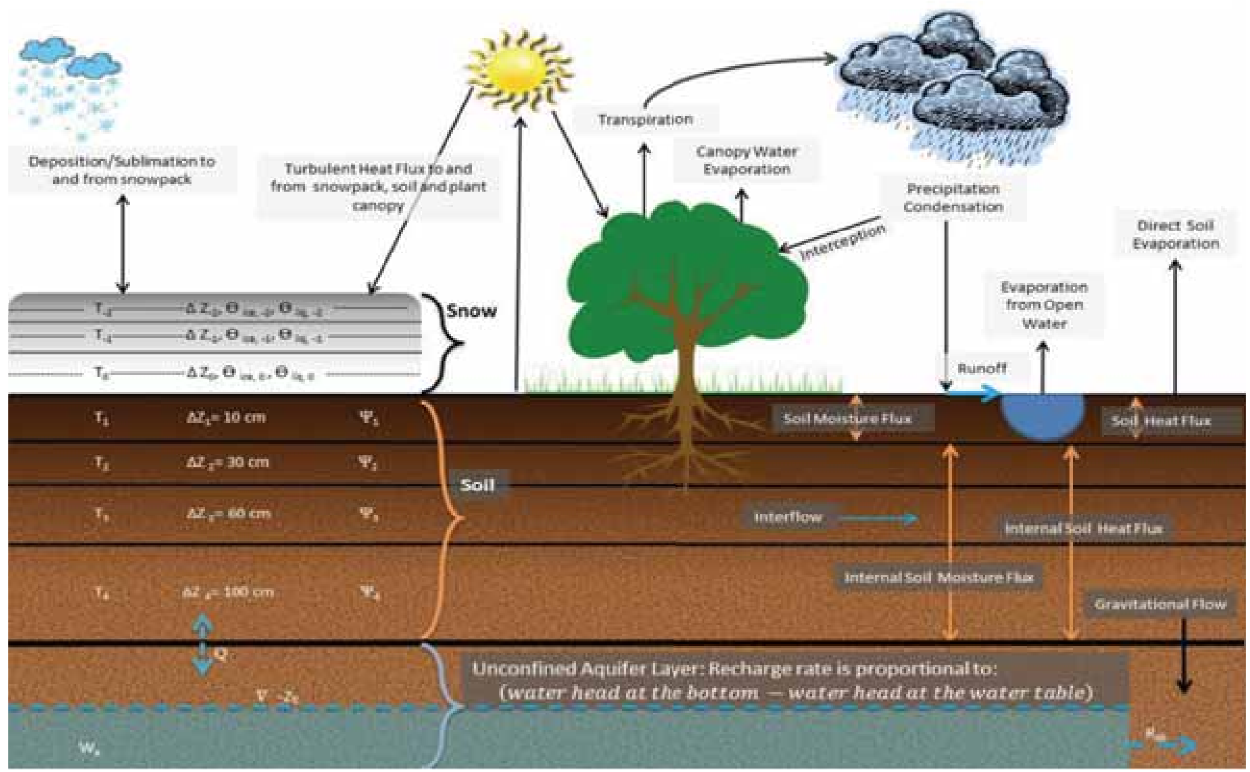
The full scheme of data processing.

WRF GRIB files contain all parameters which are necessary to calculate the flow.

We process them to get the averages for subwatersheds and load to the flow transformation model.

WRF model as datasourse

A mesoscale numerical weather prediction system (developed by NCAR, NOAA and AFWA)



Elements of water balance

- Air Temperature, degrees
- Precipitation, kg/hour m^2
- Latent Heat Flux, W/m^2
- Soil Water Content, kg/hour m^2

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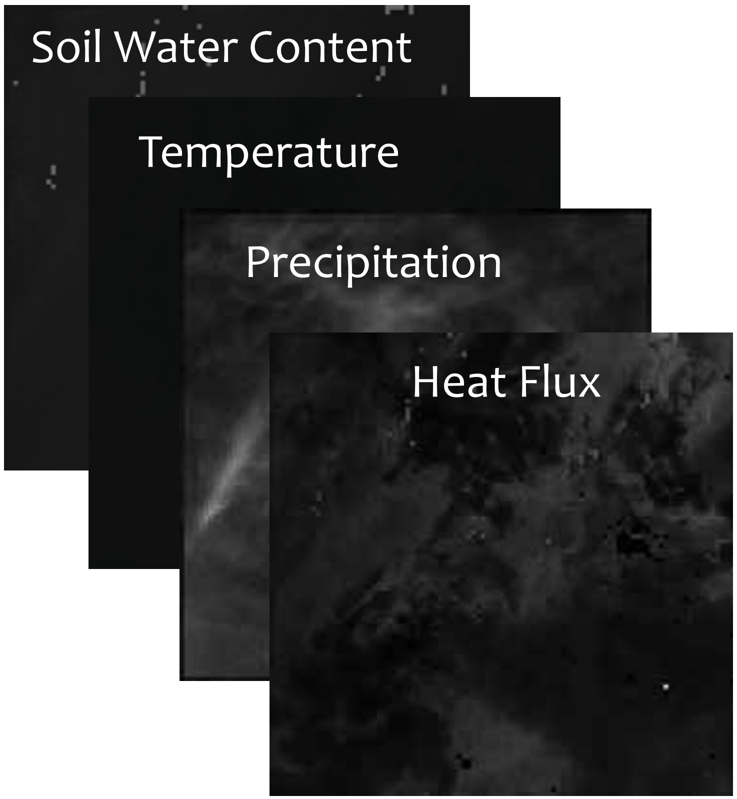
WRF model as datasourse



$$\frac{Latent\ Heat\ Flux}{Specific\ Latent\ Heat} = Evaporation$$

Specific Latent Heat = 2260 kJ/s m²

y = P – E - Infiltration

Infiltration = f(WaterContent)

All values are calculated hourly

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WRF model as datasourse

Y – flow

SM – soil moisture

E – evaporation

X – precipitation

Additional Data correction was performed

X > 0

- **dSM < 0** → **Ecorr = E + dSM**
- **dSM > 0** → **Xcorr = X - dSM**

→ **Y = Xcorr - Ecorr**

X = 0 → **dSM > E** → **dY = dSM - E** → **Y = Y + dY**

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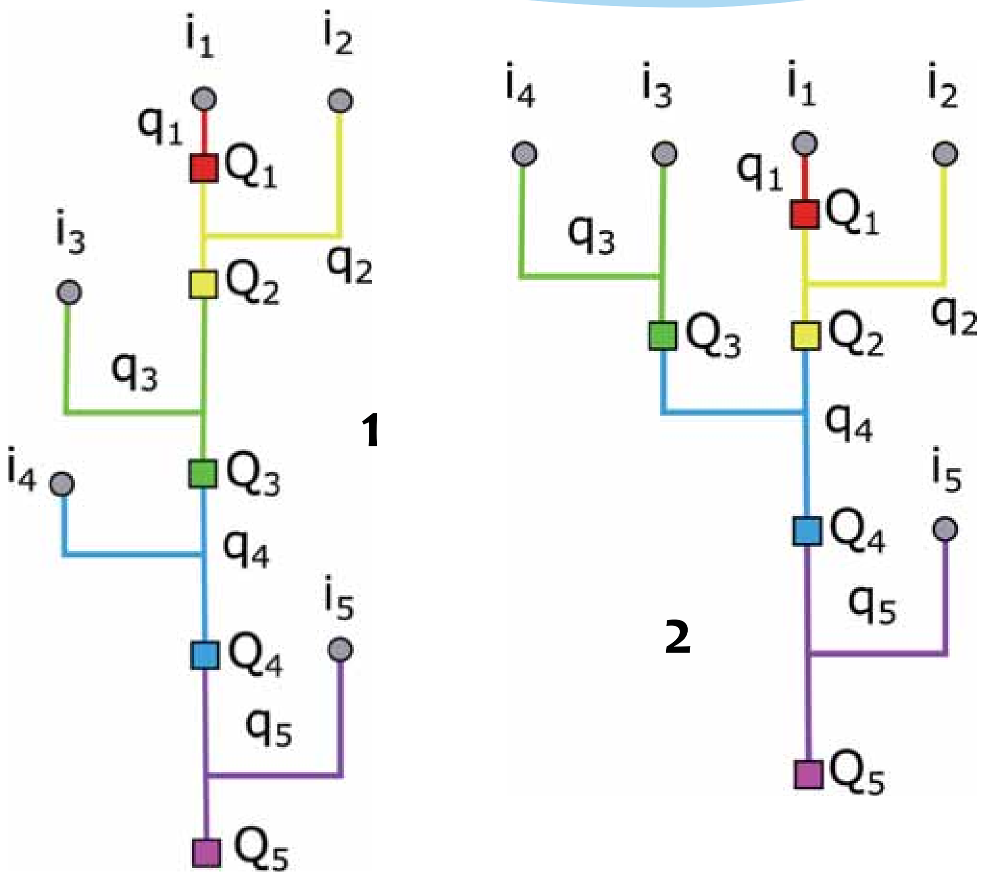
Transformation model

Two schemes of river network:

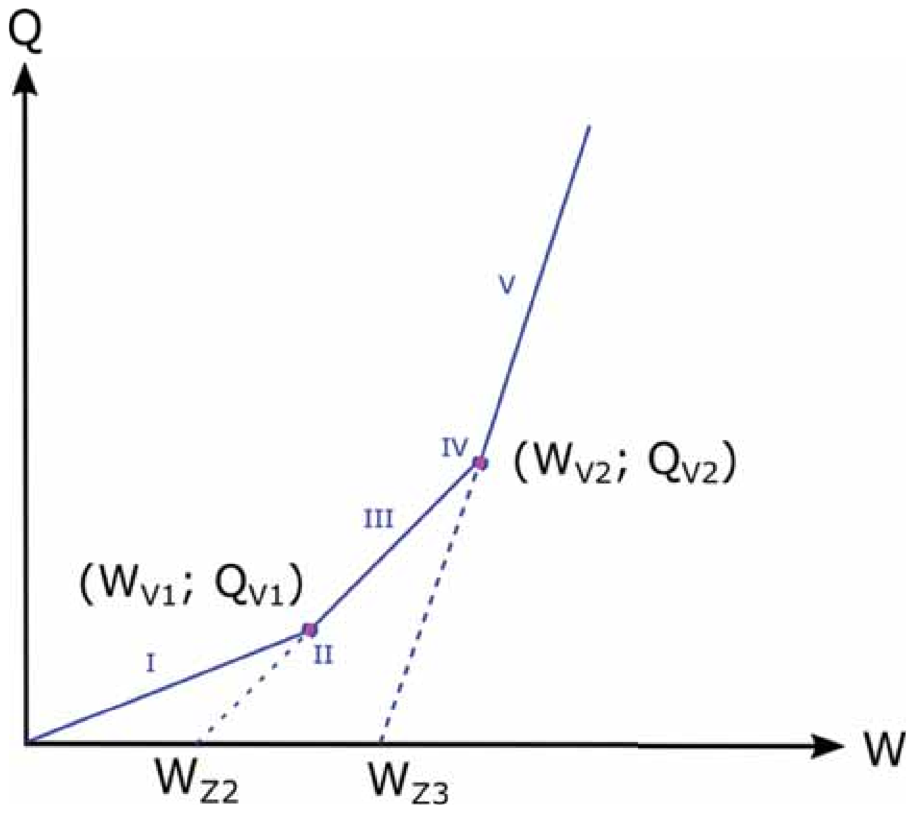
1. Sequential
2. Bifurcated

i – is initial flow concentration to the source of the first reaches
q – is a lateral flow to each river reach
Q – is a discharge at a lower cross section



Transformation model

Q-W polyline expressing water charge of a channel section depending on changing discharge.



Q is discharge m^3/s,
W is volume of water in the channel section
I—V are different conditions of water charge in the channel section.

Transformation model

Change of the volume can be written as:

$$\frac{dW(t)}{dt} = q - Q(t)$$

Equation for each part of the polyline is following:

$$W(t) = \tau \times Q(t) + W_Z$$

So volume and discharge in the next time step can be calculated as following:

$$\begin{cases} \hat{Q}_{i+1} = (Q_i - q) \times \exp\left(-\frac{t_{i+1} - t_i}{\tau}\right) + q \\ \widehat{W}_{i+1} = \tau \times \hat{Q}_{i+1} + W_Z \end{cases}$$

Solution of this equation system for every possible filling of river sections is the task of the program.

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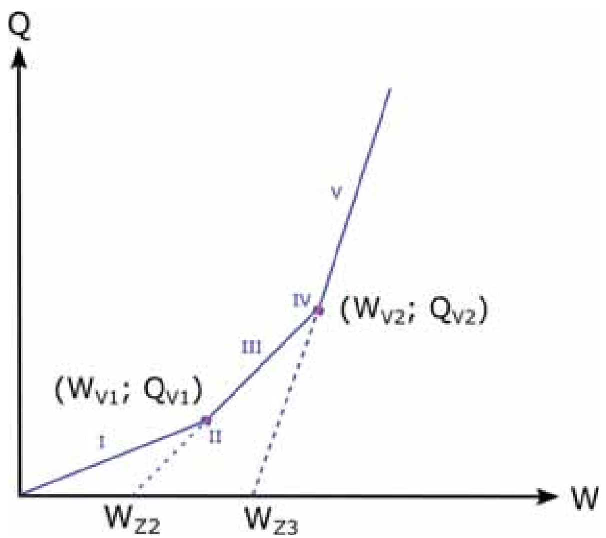
Transformation model

$$\theta = t_i - \tau \times ln \frac{q - Q_\theta}{q - Q_i}$$



For every initial Q we can calculate the value and the moment when the discharge reaches this value

Q_i *and* q ⟹ Q_{i+1} *and* $\bar{Q}_i$

The lower section **ponds the upper one,** so a part of the section flow is "returned " upwards.

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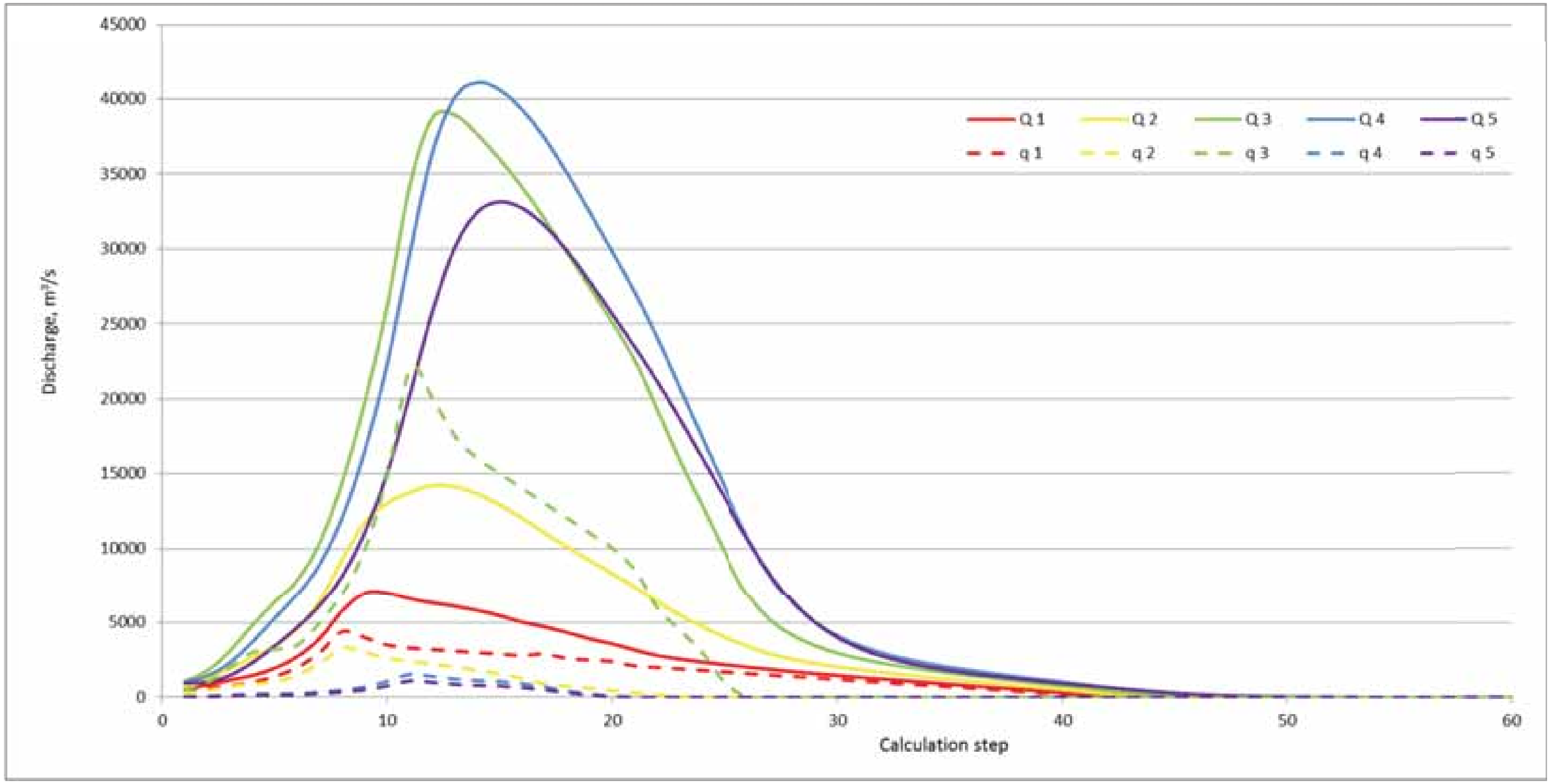
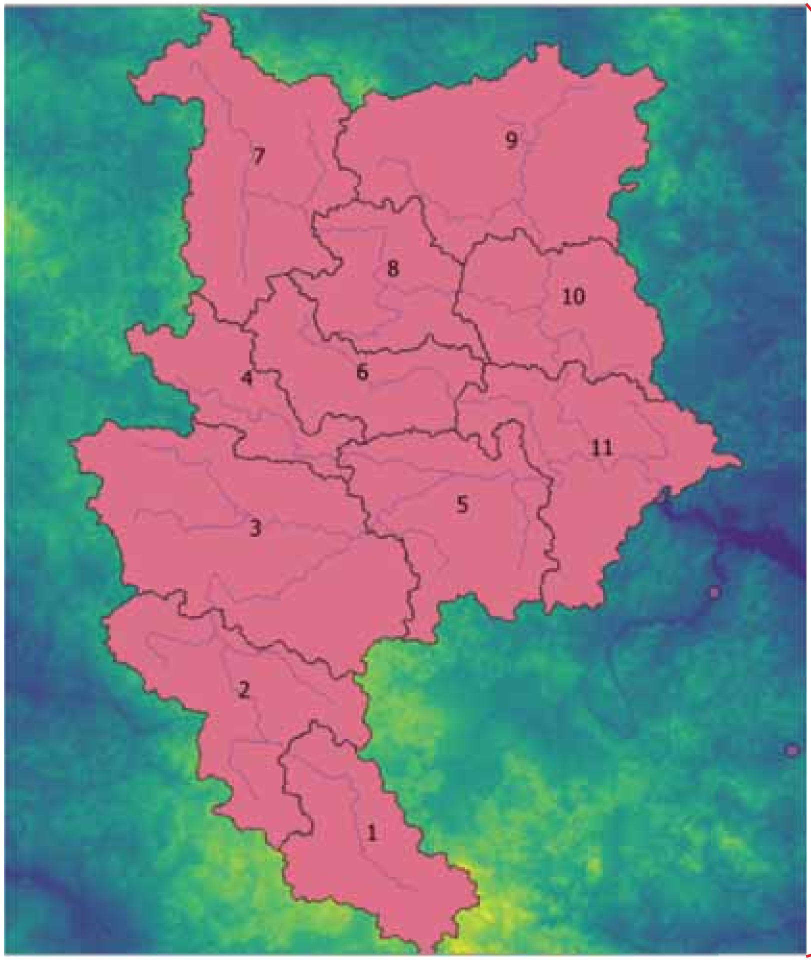
Transformation model

Testing the transformation model on artificial data of q for sequential structure



Object of Study



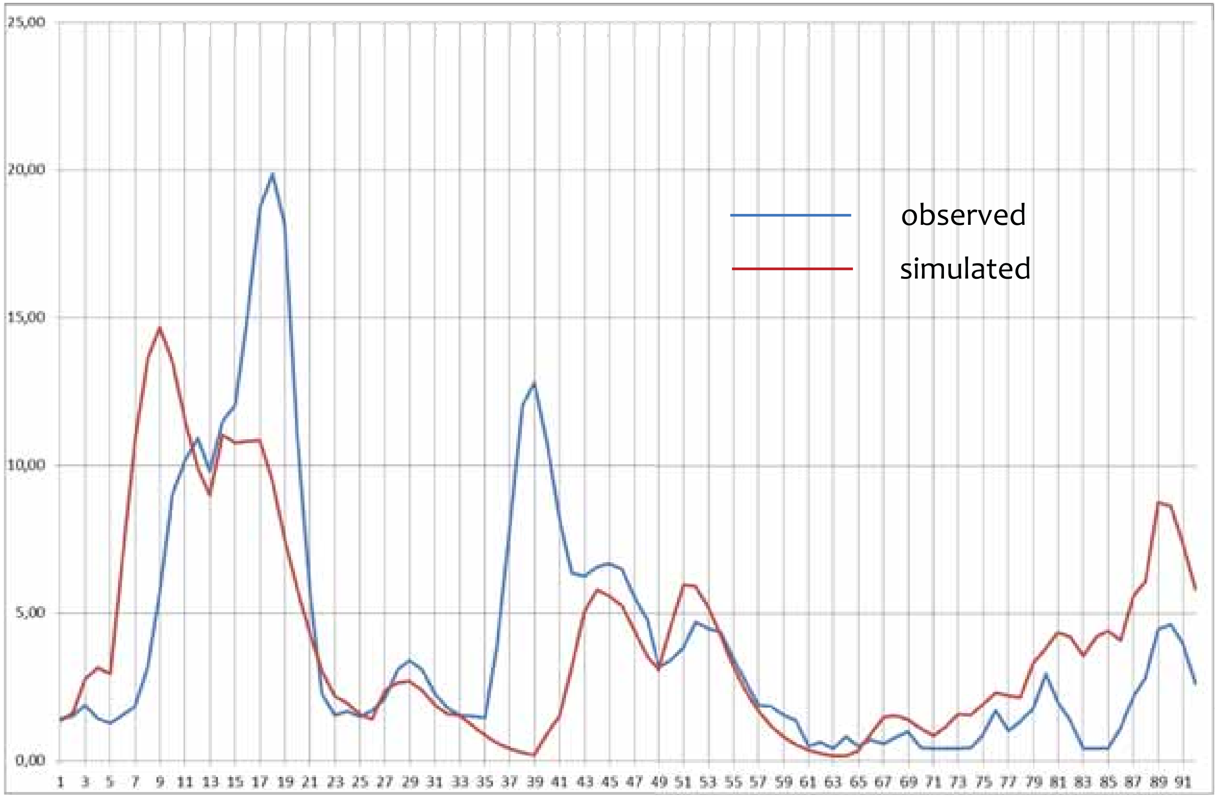
Watershed of the Upper Moskva river, the main affluent of the Mozhajskoe water reservoir

- Area = 758.9 km^2
- 65% under forest
- Average river slope = 0.004

Results of Simulation

First Simulation on real WRF data:

If E > X | **E = 0**



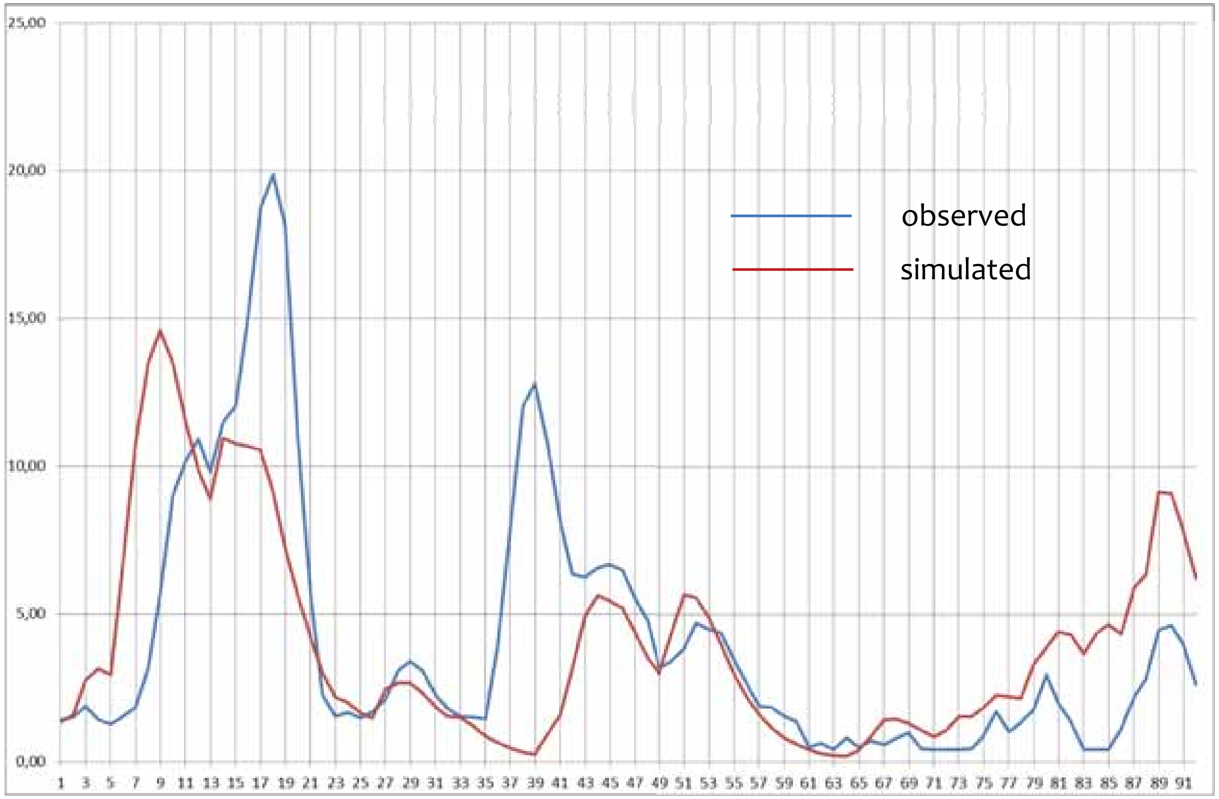
Results of Simulation

Simulation on real WRF data with corrections:

X > 0	dSM < 0	Ecorr = E + dSM
	dSM > 0	Xcorr = X - dSM
X = 0	dSM > E	dY = dSM - E

Y = Xcorr - Ecorr

Y = Y + dY



Results of Simulation

If $X_{WRF} > Xg_{max}$

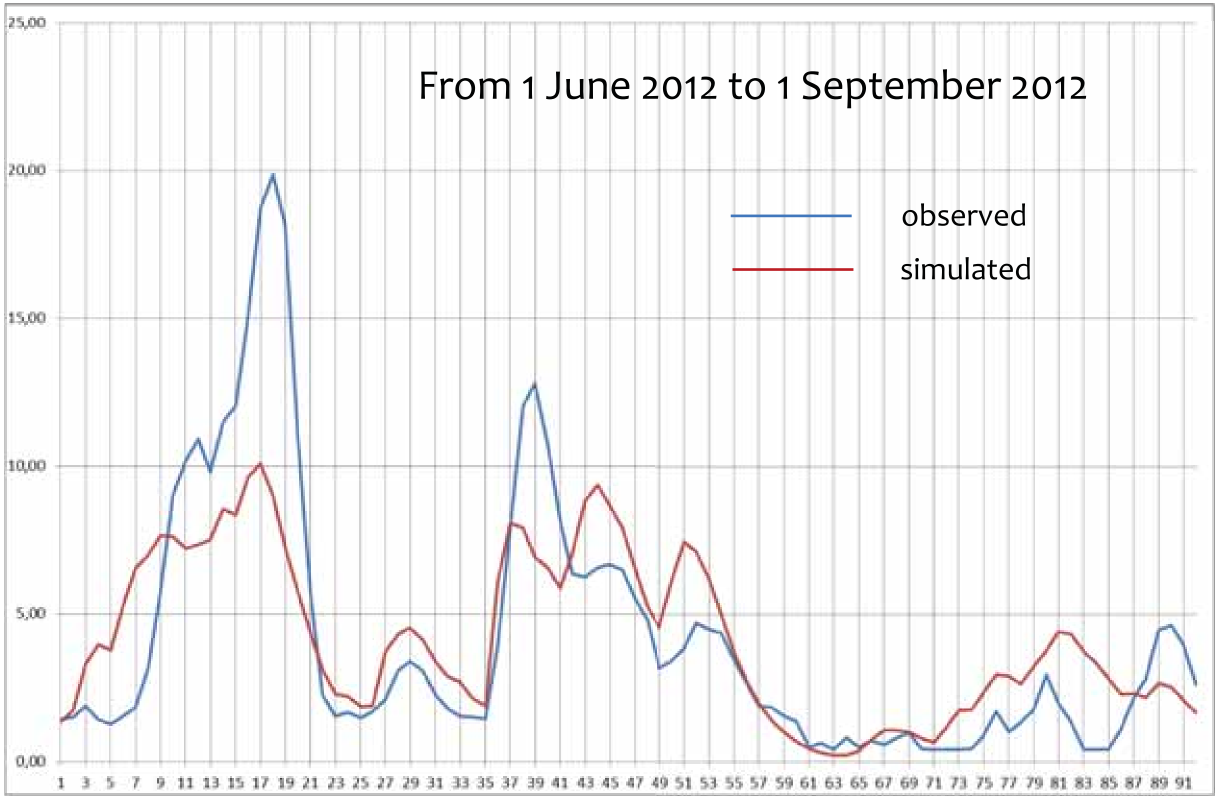
$K = (X_{WRF}/Xg_{max})$

If $X_{WRF} < Xg_{min}$

$K = (X_{WRF}/Xg_{min})$

$Xg_{max/min}$ calculated as average of precipitation data on nearest gages

X_{WRF} calculated as weighted average of WRF precipitation data for all subbasins



Conclusions

The advantages of the proposed algorhytm:

- Maximum use of atmospheric models data
- No need of additional field data (landuse, morphometry, soil information)
- Very fast to set up
- Easy to tune and calibrate

In this study we show that:

- Hydrological modelling can be simple and operative
- Meteorological models give all necessary information for flow calculation

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Future Developement

We plan to

- Test the method on rivers with various water regime
- Optimize the code, especially the preparatory part, written in Python
- Create a whole Python program easy to input , process data and present the results

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Thank you for your attention!

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