WATER BALANCE AND SEDIMENT LOAD ASSESSMENT USING SWAT MODEL. CASE STUDY ON RUSSIAN SUBCATCHMENT OF WESTERN DVINA RIVER

IYFSWC / ICCE CONFERENCE
27-31 Aug 2018 | Moscow

Lomonosov Moscow State University

Pavel Terskii[1], Alexey Kuleshov[2], Sergey Chalov[1]
Lomonosov Moscow State University, Russian Federation (1)
Dresden University of Technology, Germany (2)
email: pavel_tersky@mail.ru

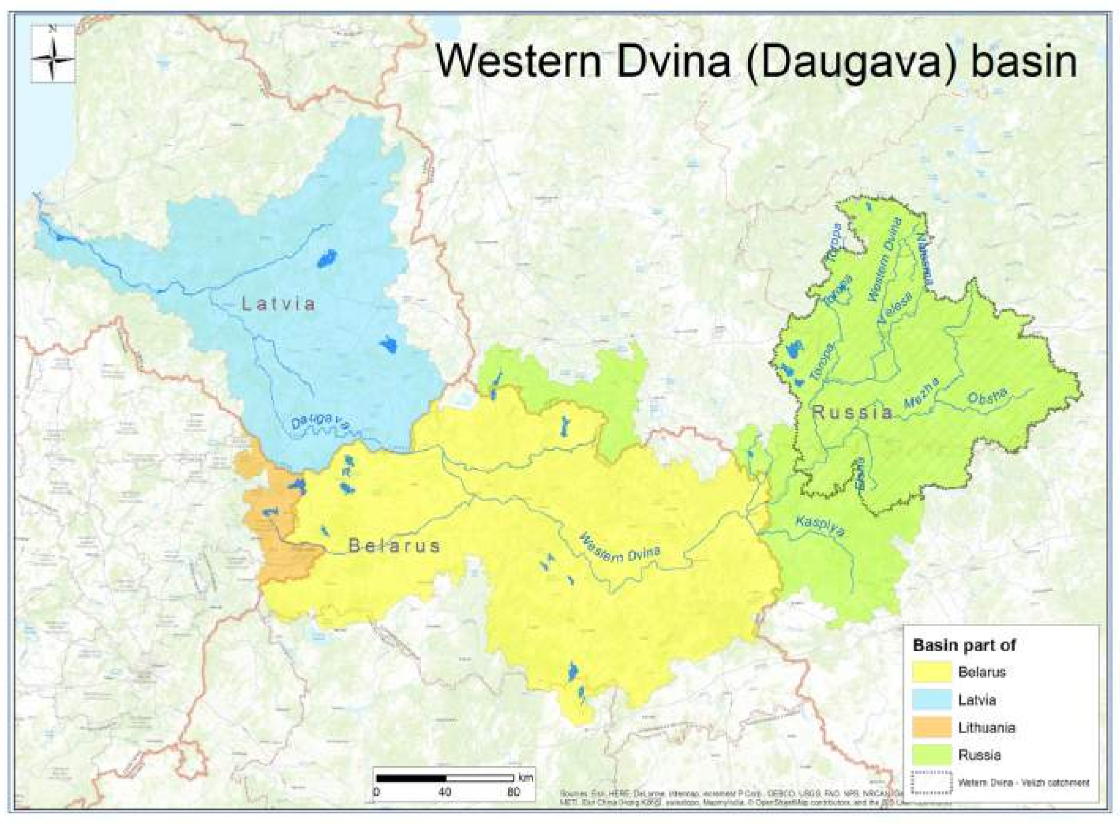
TECHNISCHE UNIVERSITÄT DRESDEN

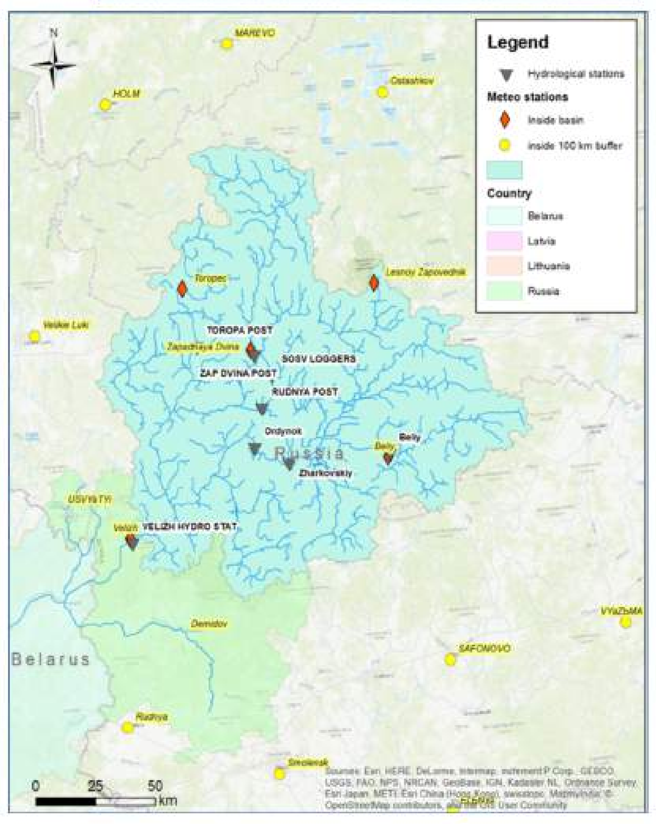
Background

MANTRA-Rivers project (Management of Transboundary Rivers) is funded by the Volkswagen Stiftung Foundation to provide transnational system analysis and dialogue within IWRM (Integrated Water Resources Management). The European Union, Ukraine and Russia share various river basins such as Western Bug, Desna and Western Dvina (Daugava).

OBJECTIVES of the study

1) To develop catchment-based system of water resources and pollution assessment
2) To create unified tool for water quality, quantity and sediment load evaluating
3) To understand influence of catchment processes on water resources





Sources & data

Meteorological data processing:

1. Plausibility analysis, detection of outliers
2. Regionalization of station data

$$r = \frac{1}{(n-1)} \cdot \sum_{i=1}^{n} \frac{(x_i - \bar{x}) \cdot (y_i - \bar{y})}{(x_i - \bar{x})^2 \cdot (y_i - \bar{y})^2}$$

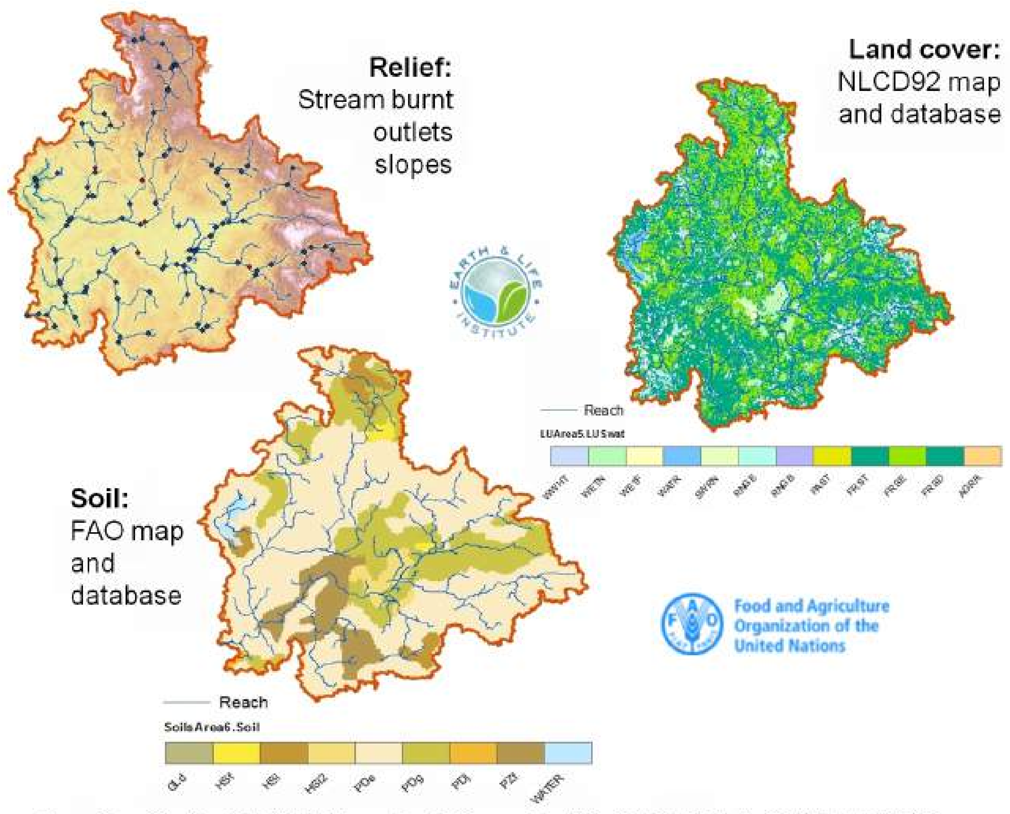
$$d = 1 - \frac{\sum_{i=1}^{n}(y_i - x_i)^2}{\sum_{i=1}^{n}(|x_i - \bar{y}| + |y_i - \bar{y}|)^2}$$

CDIAC, NOAA, ECA&D, ECMWF

Which data should be used for modeling?

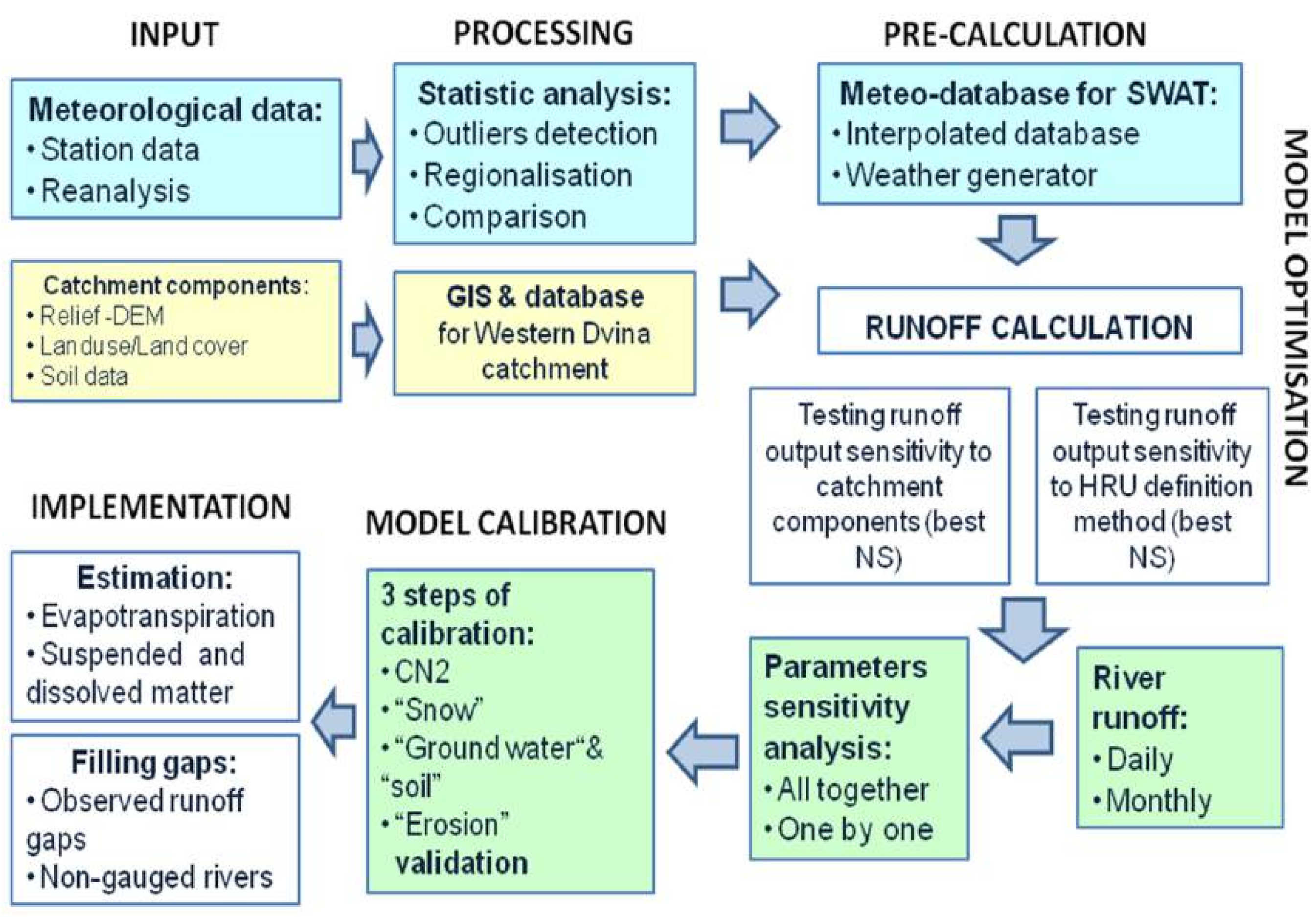
	Interpolated Station Data	Reanalysis
Availability of data	PCP, Tmin, Tmax, HU, FF	PCP, Tmin, Tmax, HU, FF, SSRD
Problems	absence of SSRD	PCP

Authors would recommend using the values obtained by interpolated stations data with SSRD from ERA-Interim reanalysis



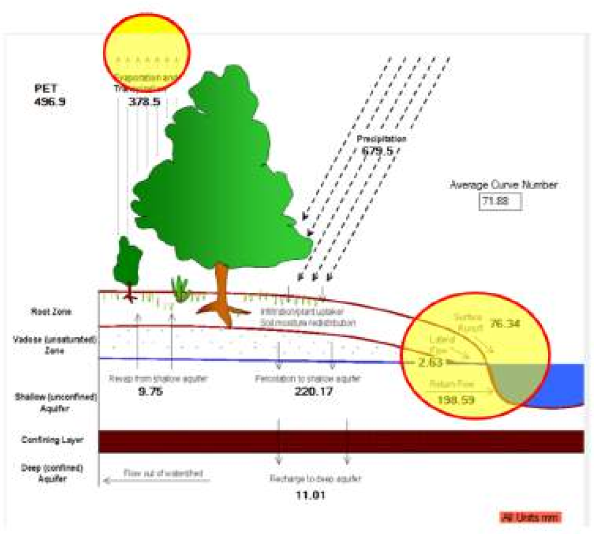
1. Relief. SRTM v.4, 30m & ALOS PALSAR RTC 12.5 m. (https://www.asf.alaska.edu).
2. Soil. HWSD FAO (http://www.fao.org)
3. Land cover. GLOBCORINE 300 m (http://due.esrin.esa.int) & Global Land Cover, 30 m (http://www.globallandcover.com)

Modeling approach



Main results

Water balance means (1989-2004)

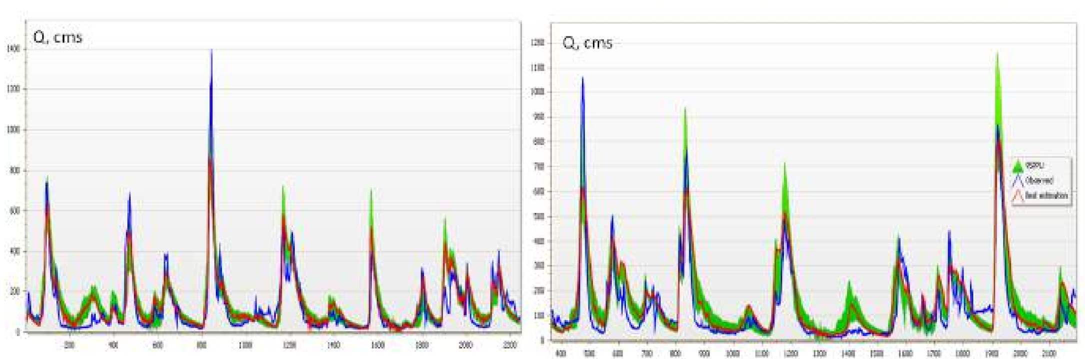


Surface runoff 278 mm simulated (275 mm – observed)

• Annual ET 378 mm simulated (395 mm – MODIS based)

Runoff calculation

ET method – plant ET, Penman-Monteith, Ch routing - Muskingum



Calibration 1992-1998

R2	NS	PBIAS	KGE
0.77	0.76	-11.7	0.8

Validation 1999-2004

R2	NS	PBIAS	KGE
0.78	0.76	-16.5	0.75

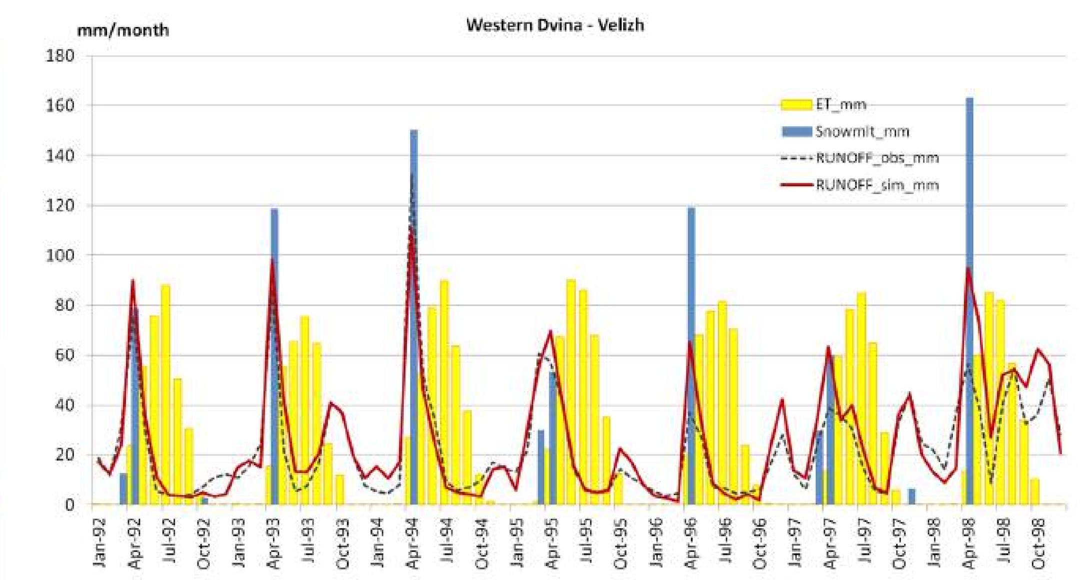
#	Parameter
1	CN2_FRSE,FRSD,FRST
2	CN2_RNGE,WWHT
3	SFTMP
4	SMTMP
5	SMFMX
6	SMFMN
7	SNOCOVMX
8	SNO50COV
9	SOL_AWC()
10	GWQMN
11	GW_DELAY
12	RCHRG_DP
13	GW_REVAP
14	ALPHA_BF
15	TIMP
16	ESCO
17	SNO_SUB_19,10,30,16,7,26,2,24,23,20,31,22,6,27,5,3
18	SNO_SUB_21,12,14,32,1,29,17,4,28,9,13,15,25,11,8,18
19	REVAPMN.gw

Runoff curve number CN2 – distributed parameter

SNOWMELT parameters – lumped - separate from others calibration

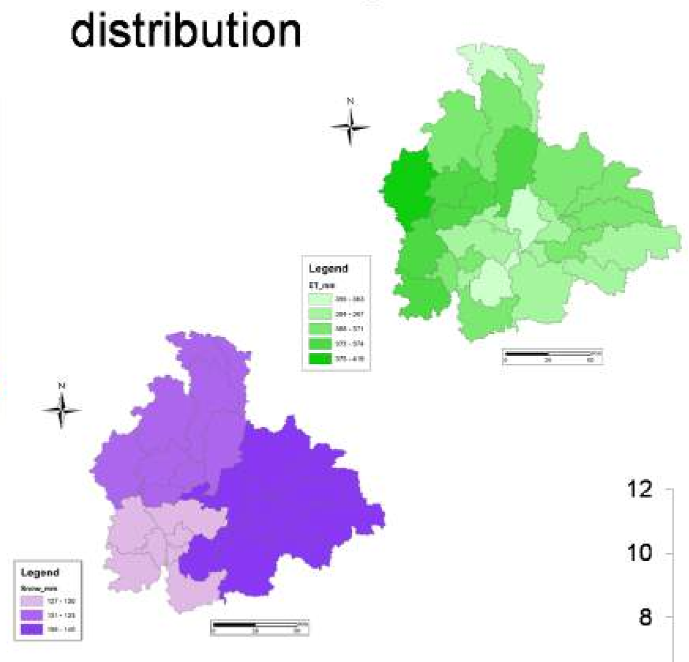
SOIL&GROUNDWATER parameters – distributed

Snow cover distribution – separate calibration. 80% forested area threshold



Water balance structure – river runoff, snowmelt water yield and evapotranspiration (example for 1992-1998)

Evapotranspiration & snow water equivalent distribution



LOADEST model:
Chosen type of model: # 1
$Ln(Conc) = a_0 + a_1 lnQ$
Diagnostics:
Bp [%] = 0.963
NSE = 0.113

Sediment load calculation

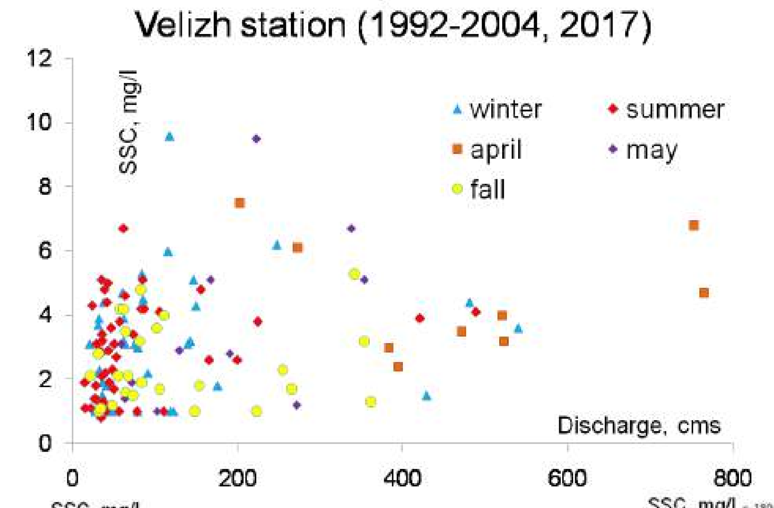
LOADEST tool (USGS): To calculate monthly load

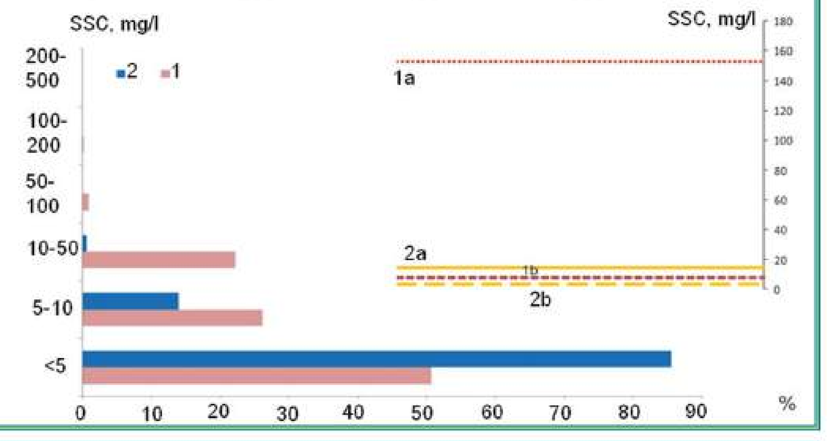
Multiple regression calculation between discharge SSC

Calculate daily sediment load

Aggregate into monthly fluxes

Measured SSC, Western Dvina – Velizh station (1992-2004, 2017)





Frequency curve and average values (a – annual maximal, b- annual mean) for SSC:
1- Mantra pilot study station, Velesa River, 2017;
2 –Western Dvina River, Velizh station, 1992-2004, 2017)

Conclusions

1. Authors recommend using interpolated observed weather data against reanalysis (except SSRD) and be "careful" with precipitation data distribution. Using detailed DEM (12.5 m) and LandCover (30 m) significantly improves results for daily time step, but almost does not have effect for monthly. Soil database should be more detailed for daily time step calculations.

2. The most sensitive are "snow" and "groundwater" parameters, and also distributed CN2 parameter. Calibration of "snow" parameters should be done separately from others. Evaporation is simulated well, but snow water equivalent is slightly overestimated (in comparison to observed SWE).

3. The most significant SSC differences are in the maximal values at Velizh, which are much smaller compared to other datasets. These discrepancies are caused by old methods and low frequency of sampling.

4. LOADEST based model for SSC calculation at Velizh can be used only for annual mean values and not for daily and monthly time series.

References:

1. https://swat.tamu.edu/ - official website of SWAT
2. Abbaspour K.C. et.al. SWAT-CUP calibration and uncertainty programs for SWAT. Proc. Intl. Congress on Modelling and Simulation (MODSIM'07). 2007. P. 1603–1609.
3. Load Estimator (LOADEST): A FORTRAN Program for Estimating Constituent Loads in Streams and Rivers. Robert L. Runkel et.al., USGS, 2004

Authors are grateful to all who helped to organize the collaboration: D.Karthe (Helmholtz Centre for Environmental Research, Germany), T.Pluntke, C.Bernhofer, B.Helm (Dresden University of Technology, Germany. This study is supported by Volkswagen Stiftung foundation (Germany) and RFBR (Russian Federation) project 15-05-05515.