# Analysis of influence of the rating curve in Warsaw on the flow conditions in the Middle River Vistula

*Emilia Karamuz*
*Marzena Osuch*
*Renata Romanowicz*

*Institute of Geophysics*
*Polish Academy of Sciences*

# Plan of presentation

- Introduction
- Study area
- Methodology
  - Implementation of rating curve (RC) uncertainty
  - Experimental design
    - Calibration scenarios
    - Sensitivity analysis
- Results
- Conclusions

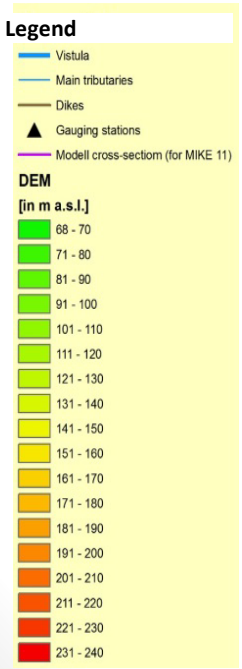
# Research questions

- assessment of the extent of the influence of the rating curve (downstream boundary condition) on the model simulations upstream.

- assessment of possible improvement of the model results in the Warsaw part of the reach.

# Study area

- 255 km river reach between Zawichost and Warsaw Port Praski (Middle River Vistula)
- 7 gauging stations
- 112 cross-sections



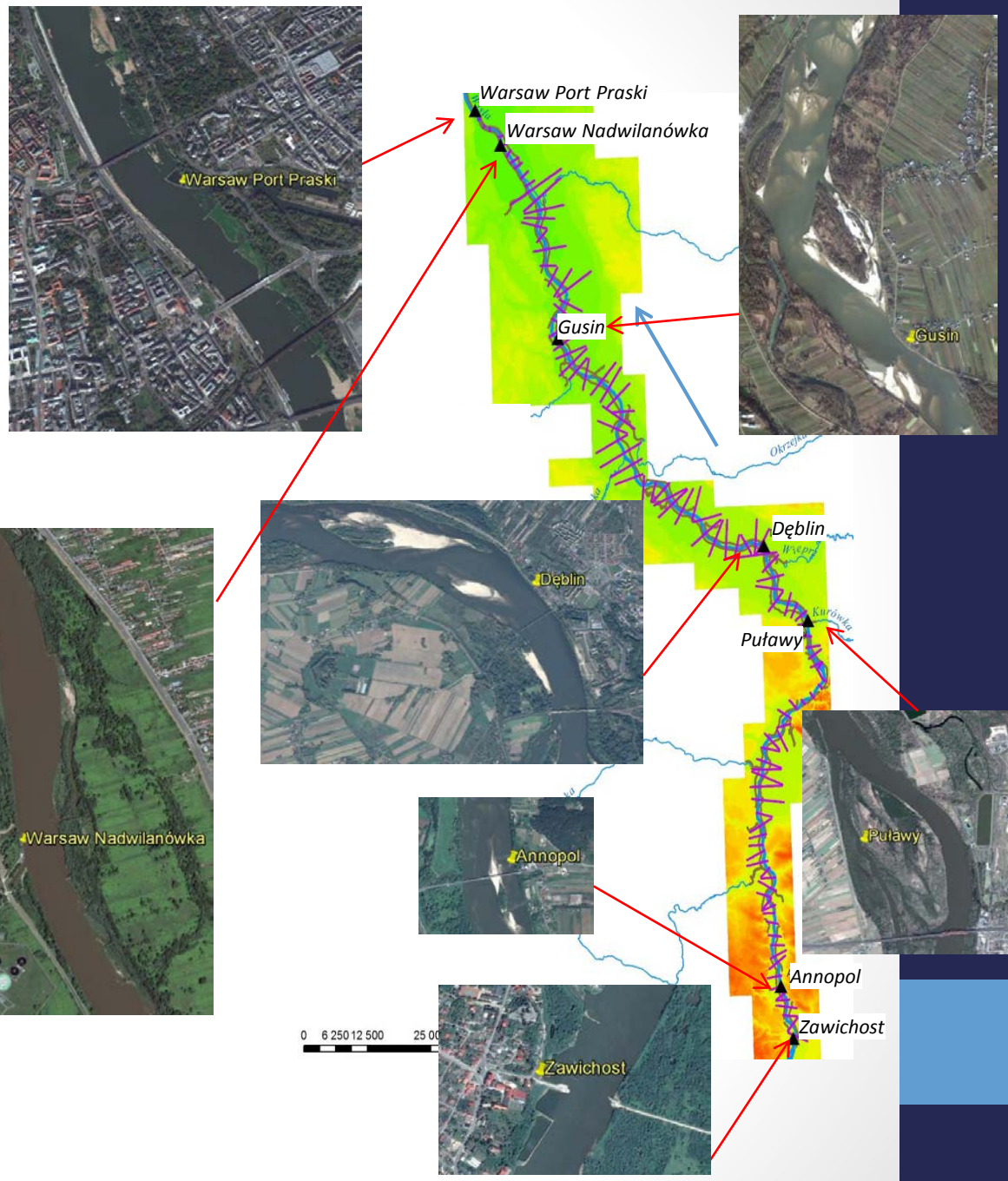
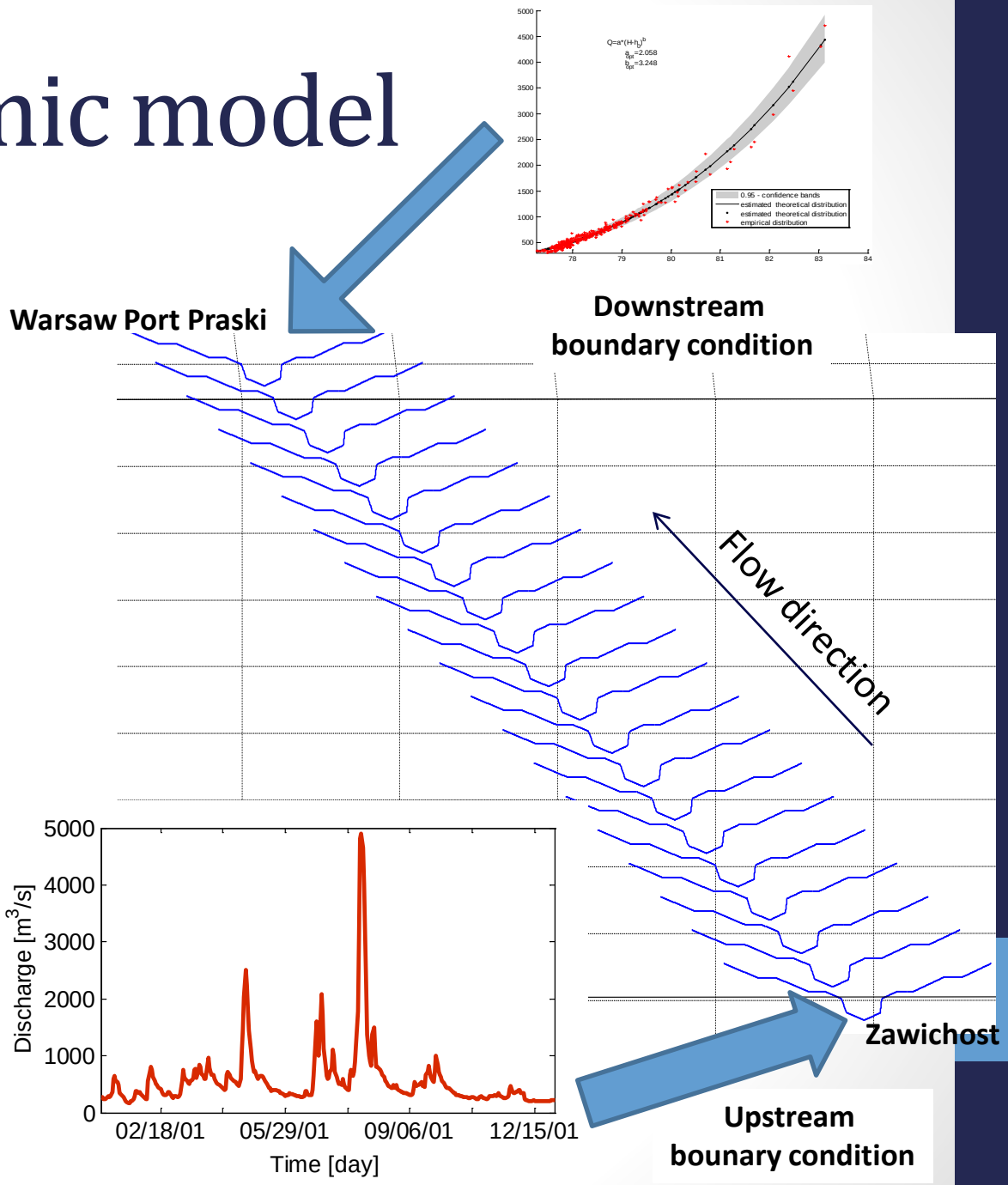




**Fig. 1.** Map of the modelled reach of the River Vistula

# Hydrodynamic model

- MIKE 11 1D for flow routing
- upstream boundary - flow hydrograph (Zawichost)
- downstream boundary - rating curve (Warsaw Port Praski)
- Water levels and discharges from 7 gauging stations
- Nash-Sutcliffe coefficient as a criterion



# Experimental design

1. **Model calibration**

**Two scenarios:**

a) **only model parameters (roughness coefficients) are optimized**

b) **simultaneous optimization of model and rating curve parameters**

2. **Sensitivity analysis**

# RC uncertainty

- $Q = a(H - H_0)^b$
  - where: *a* and *b* are optimized function parameters and $H_0$ is the water level corresponding to zero discharge, Q -discharge [$m^3/s$] and H –water level [m a.s.l.].

- Parameterization - calibration period (1.01.2001 – 31.12.2001)
- confidence limits obtained from the MATLAB CF tool
- parameter ranges were used for the model calibration, sensitivity and uncertainty analysis.

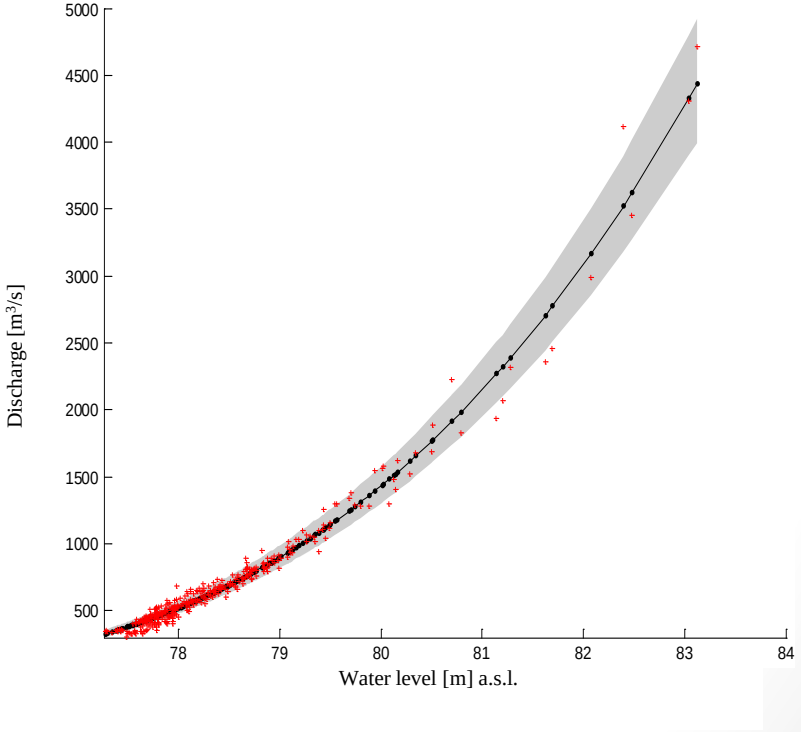


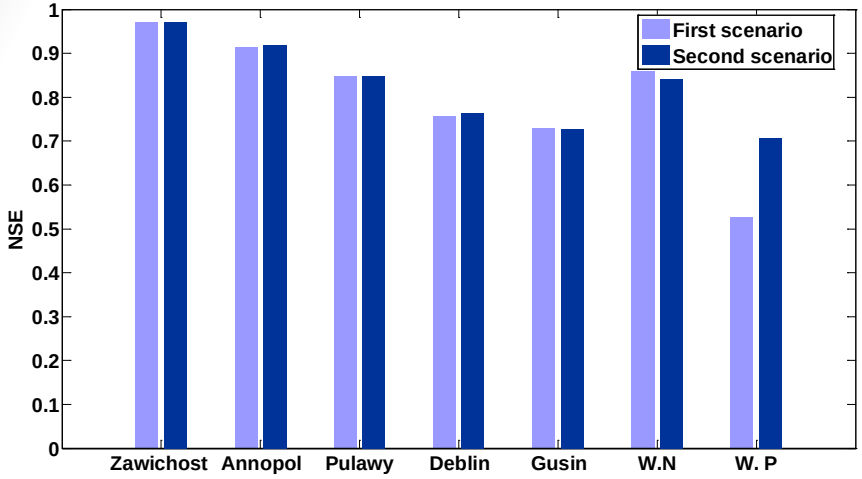

**Fig. 2.** Rating curve for Warsaw Port Praski cross-section for the year 2001

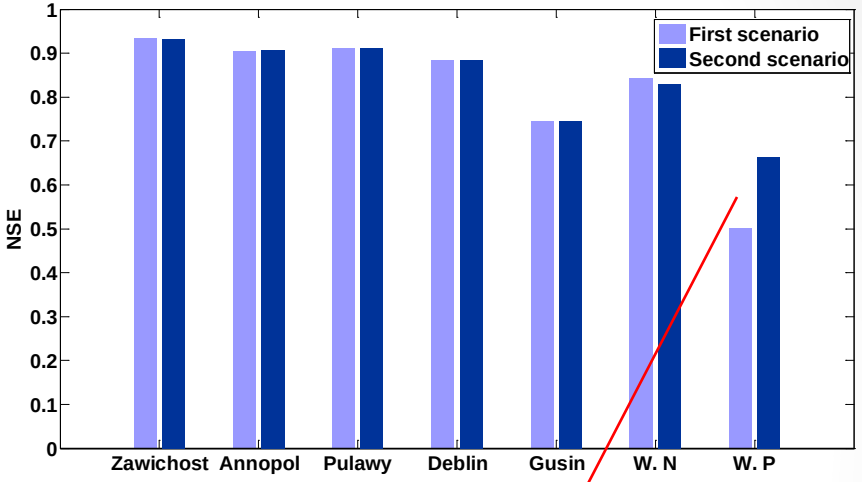
# Optimization procedure

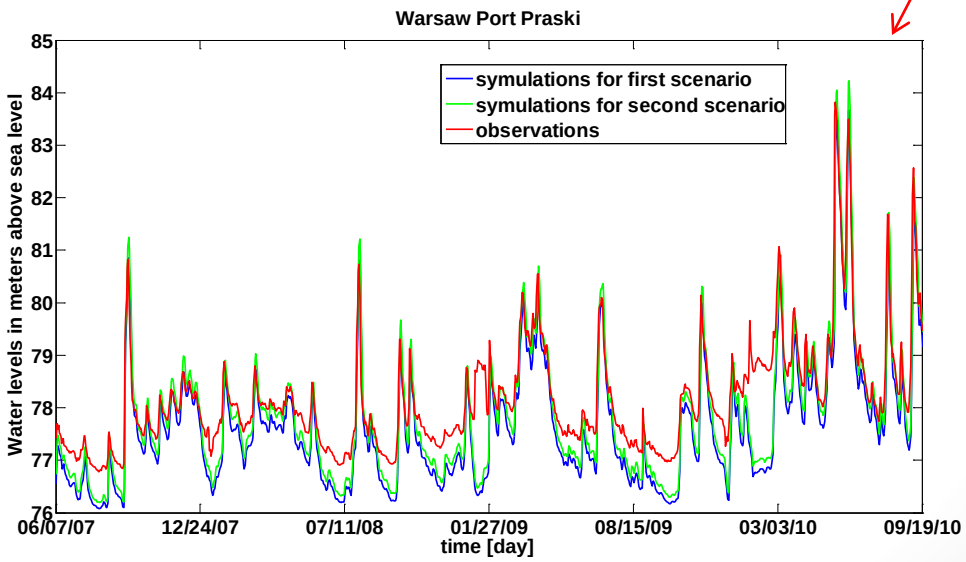
- For each scenario the optimization was done automatically using the Simplex Nealder-Mead algorithm
  - observed time series (water levels and flows) for the year 2001.
  - parameter ranges of:
    - Manning coefficient [0.01 0.2]
    - RC parameters ranges: *a* [1.913 2.204] and *b* [3.213 3.283]
- Evalution - NS criterion for water levels and discharges for seven gauging stations
- Objective function J - sum of NS values for all analysed gauging stations estimated for water levels and flows
- Multiple starting points of the algorithm

# Results of optimisation: second research question

A comparison of the calibration and validation results at seven gauged cross-sections for two scenarios.



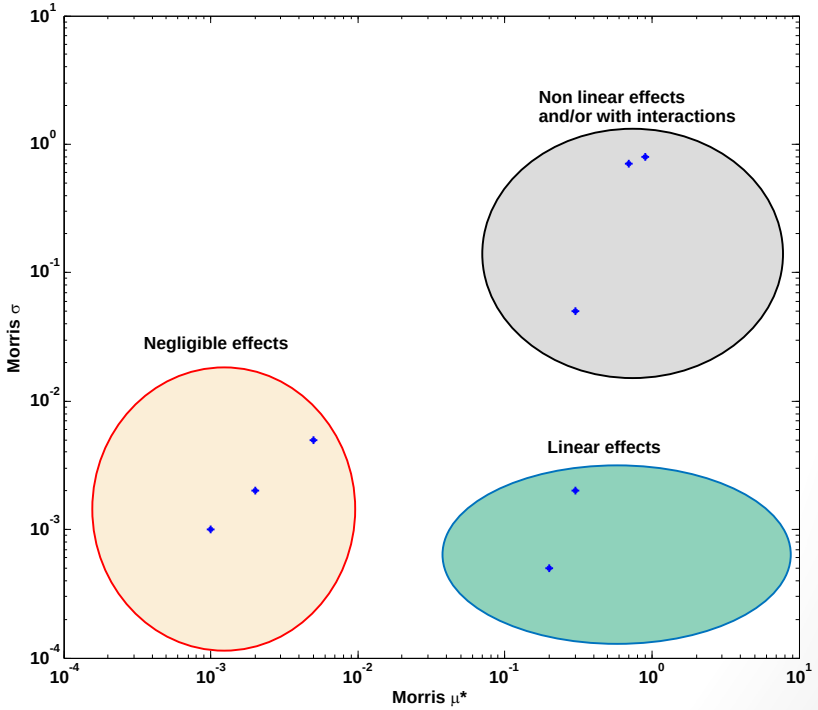



# Sensitivity Analysis: Morris method

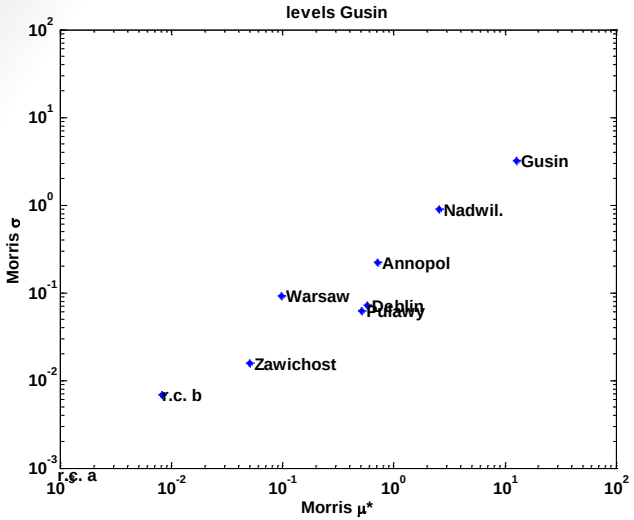
- Sensitivity is estimated on the basis of a number of local changes at different points in the possible range of model parameters, called the elementary effects. The global results are obtained by regional exploration of the input space (a chosen number of trajectories).

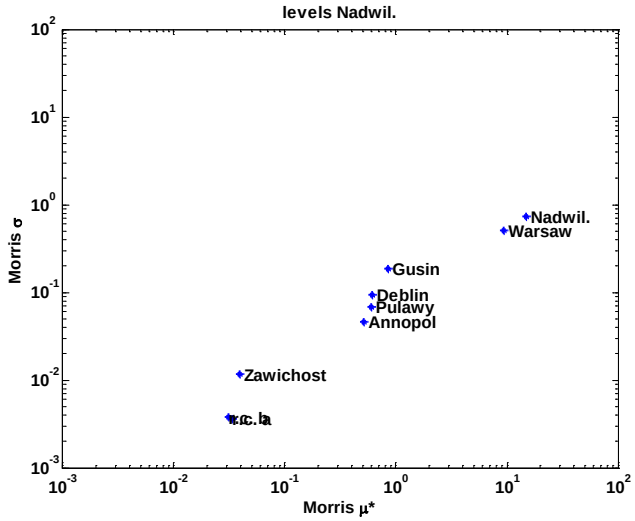
The results of this method are presented in the form of two measures:

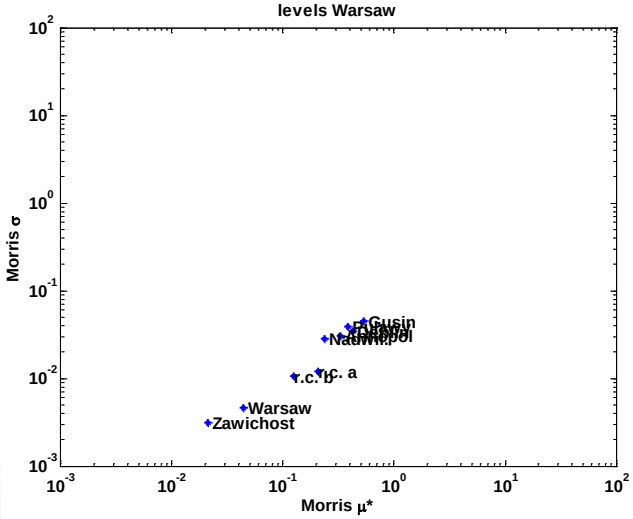
- The first measure, $\mu_i^*$ , represents the overall influence of a factor/parameter i on the output
- The second measure, $\sigma_i$ , estimates the ensemble of the factor's higher order effects (i.e. nonlinearity or interaction with other parameters) for parameter *i*.



# Results of sensitivity analysis: 1st research question



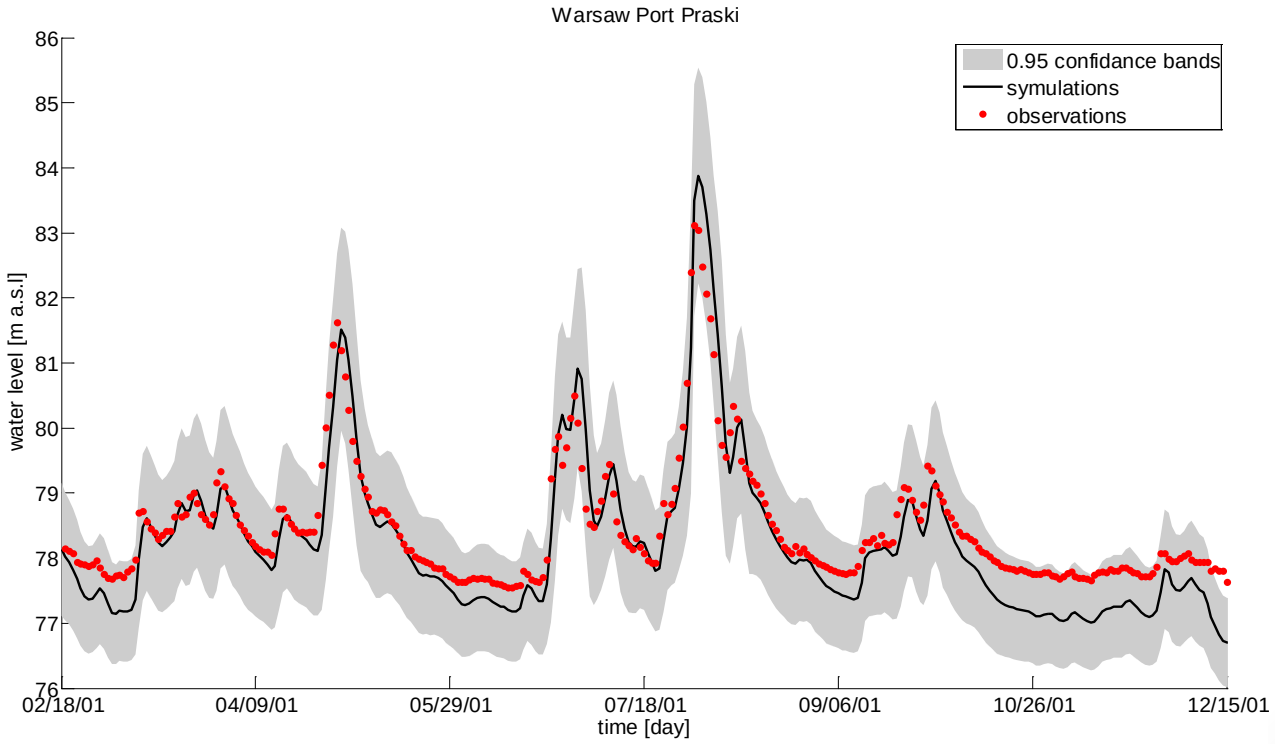




- Only in the case of Gusin, Nadwilanówka and Warsaw Port Praski gauging station the estimates of μ* are higher than zero indicating small influence on model output.
- The sensitivity analysis indicates that the downstream boundary condition influences mainly Warsaw Port Praski results.

# Uncertainty of model predictions

Water level predictions at Warsaw Port Praski gauging stations with 0.95 confidence limits obtained using Generalised Likelihood Uncertainty Estimation (GLUE)



# Conclusion

- The results of sensitivity analysis indicated that the influence of two parameters of RC in Warsaw Port Praski is negligible for all gauged cross-sections upstream of Gusin. Only in the case of Gusin, Nadwilanówka and Warsaw Port Praski gauging stations the estimates of μ* are higher than zero indicating small influence of RC parameters on the model output. This gives an answer to our first research question, regarding the extent of the influence of the downstream boundary condition.
- As could be expected, increasing the number of parameters improved model performance. The largest improvement resulted from better fit of water levels in Warsaw Port Praski gauging station. This gives the answer to the second research question

# Thank you for your attention

*Institute of Geophysics*
*Polish Academy of Sciences*