The role of daily precipitation interpolation for the SWAT model performance across different spatial and temporal scales

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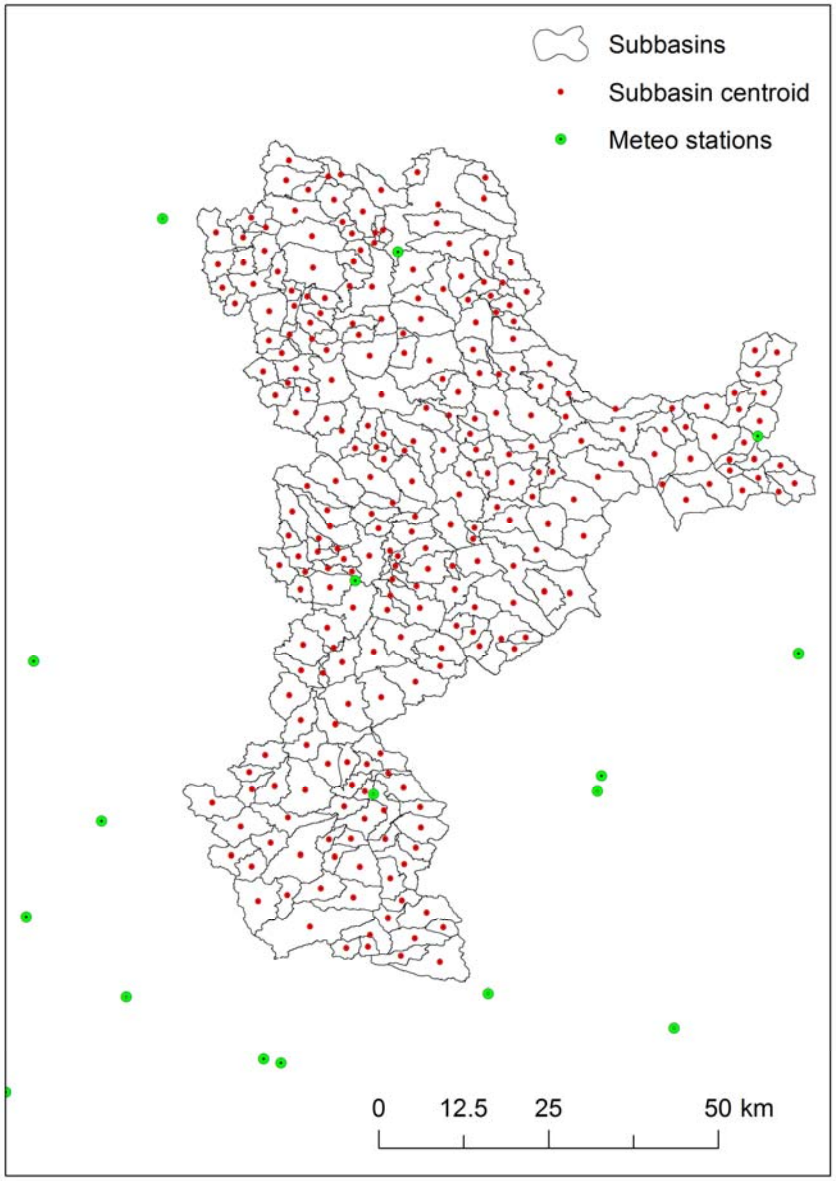
Default SWAT method

- Based on the Nearest Neighbour
- For each subbasin the amount of precipitation is taken from the nearest station
- Missing values replaced by SWAT built-in Weather Generator (WXGEN)



Objectives

- Do selected spatial interpolation techniques can improve the performance of the SWAT model in predicting flows in differrent spatial and temporal scales?

Case studies

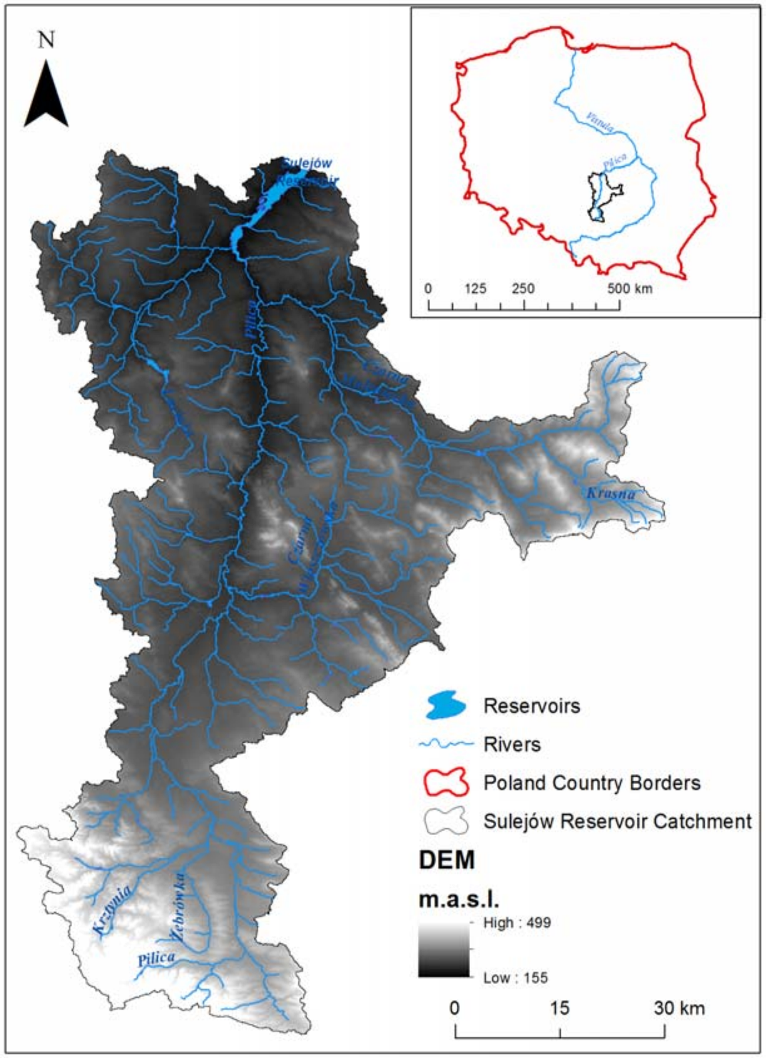
- Case one: 11 meso-scale (119 to 3935 km^2) sub-catchments lying in the Sulejów reservoir catchment – finished and published*

- Case two: 80 catchments (500 to 3000 km^2) Vistula and Odra Basins – ongoing study

* Szcześniak, M., & Piniewski, M. (2015). Improvement of Hydrological Simulations by Applying Daily Precipitation Interpolation Schemes in Meso-Scale Catchments. *Water*, *7*(2), 747-779.

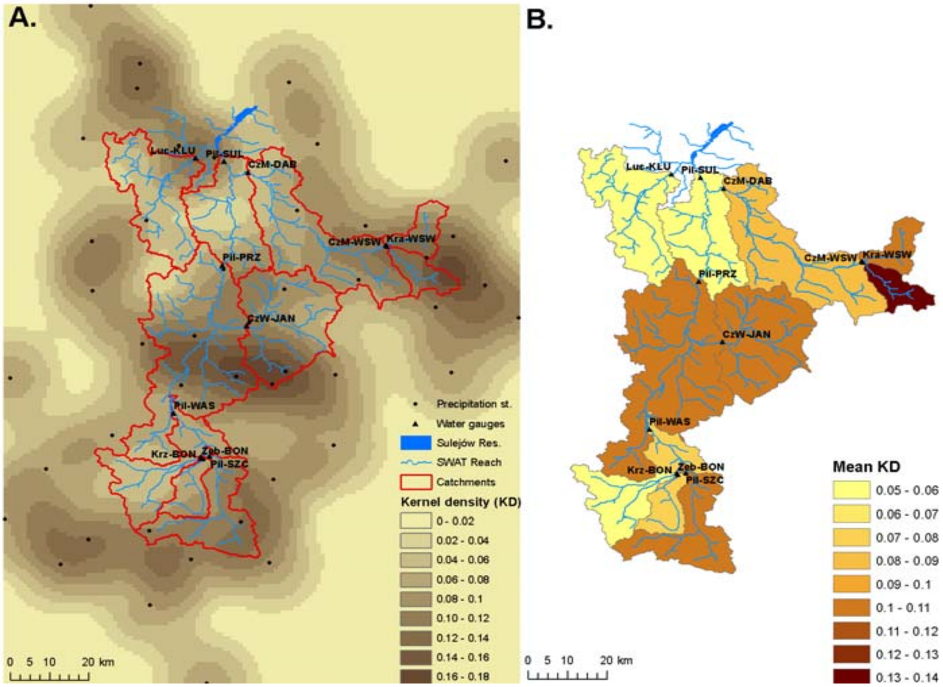
Sulejów reservoir catchment

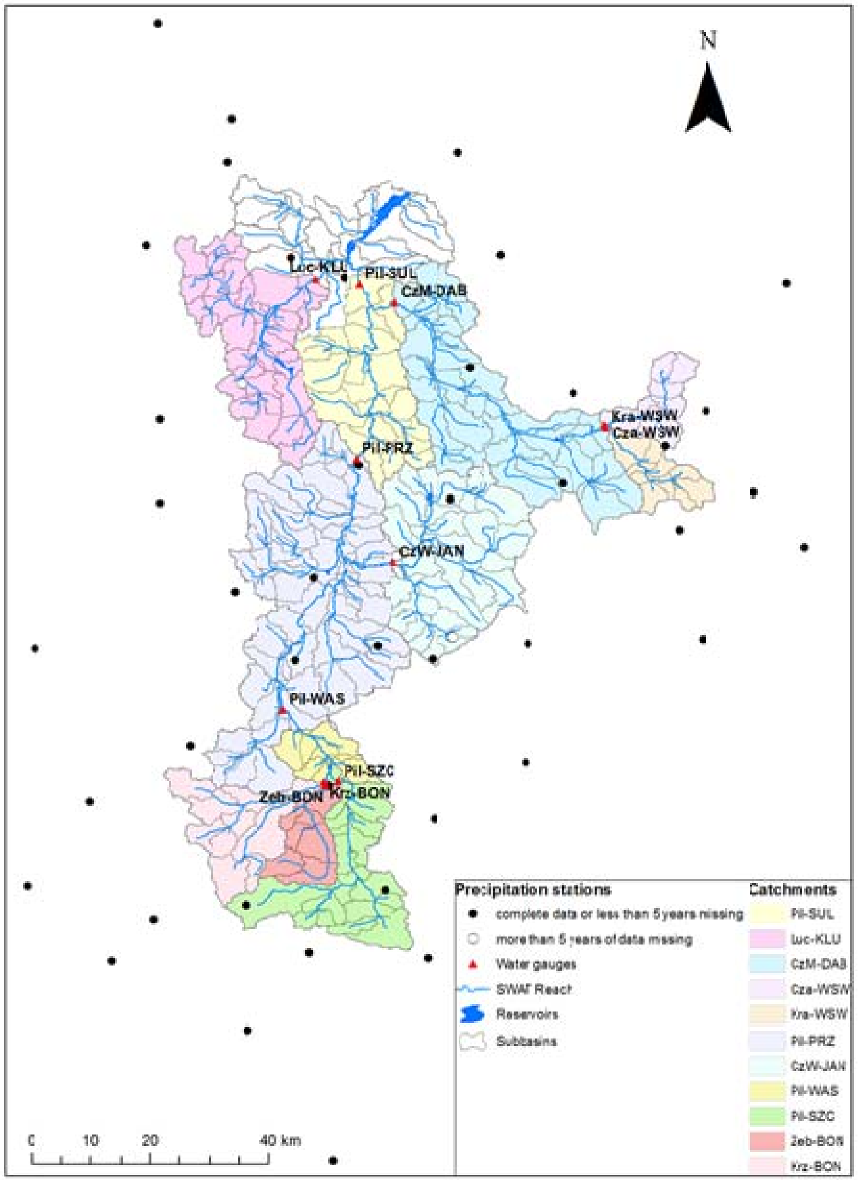
- Part of the Pilica River catchment, located in the central Poland
- Total area 4,928 km^2



Meteo inputs

- 49 stations, mainly precipitation
- 30 years of daily data

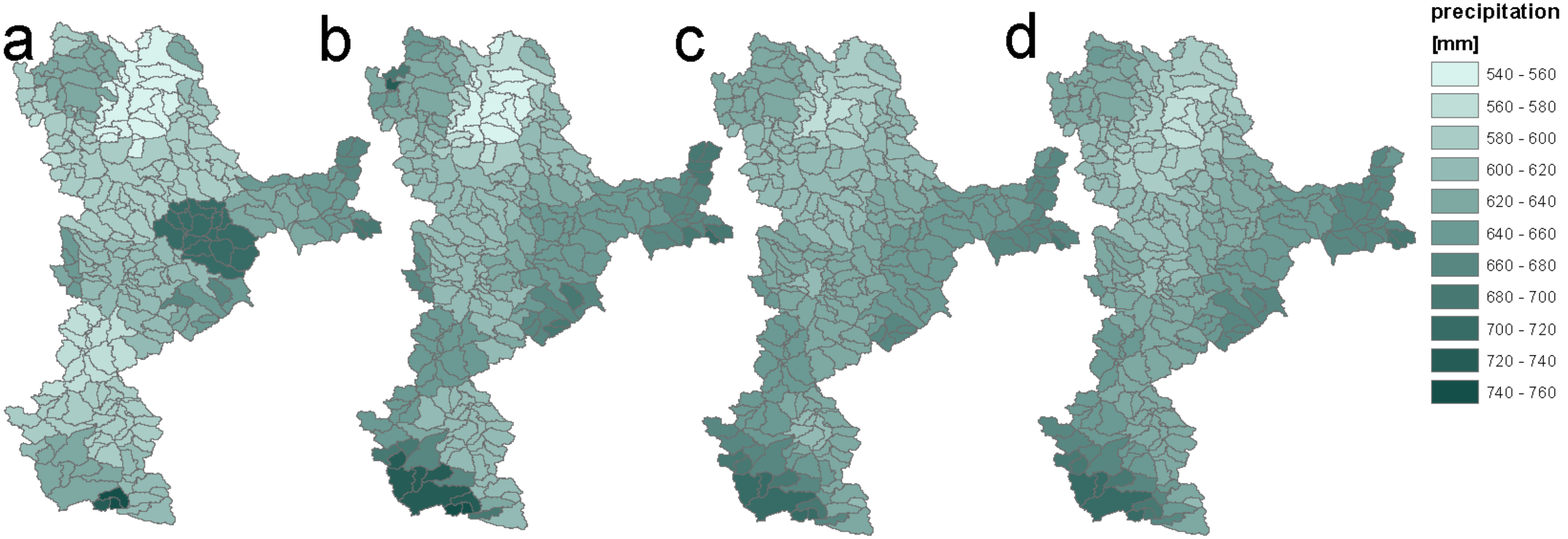




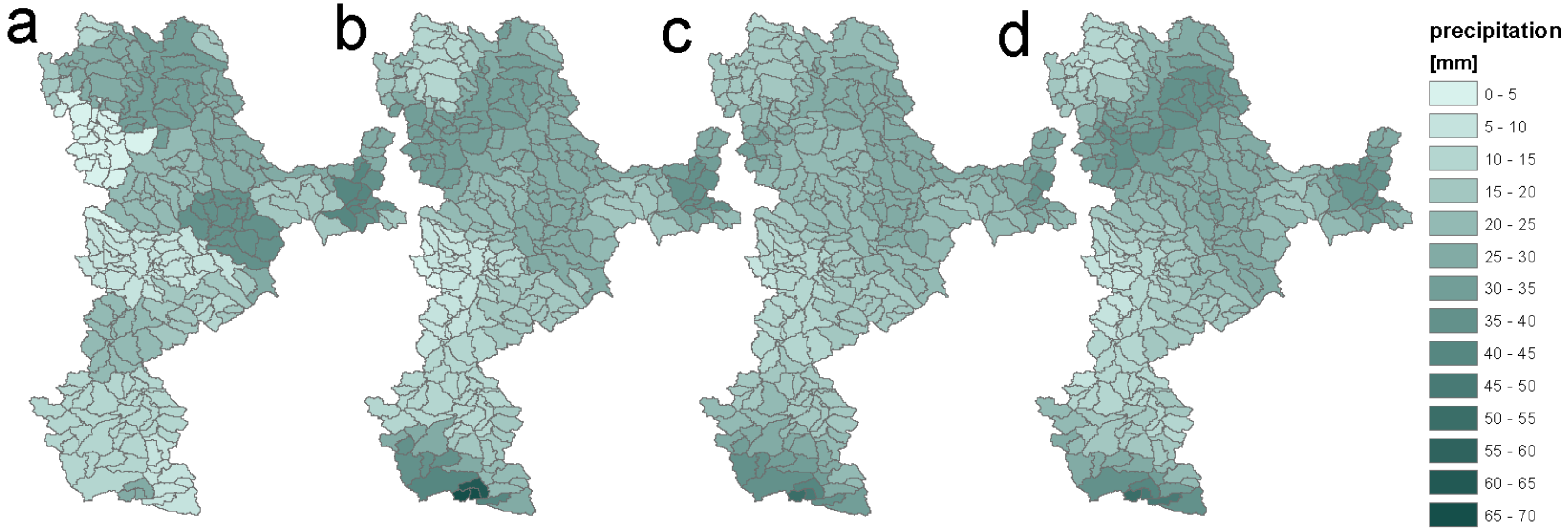
Used methods of spatial interpolation

- Aside of the default SWAT method (Def), three methods were used:
  - Thiessen Polygons (TP)
  - Inverse Distance Weighted (IDW)
  - Ordinary Kriging (OK)

- SWAT-CUP SUFI-2 algorithm was used as a tool for evaluation of the results



Mean yearly
precipitation (30y)
a – Def
b – TP
c – IDW
d - OK



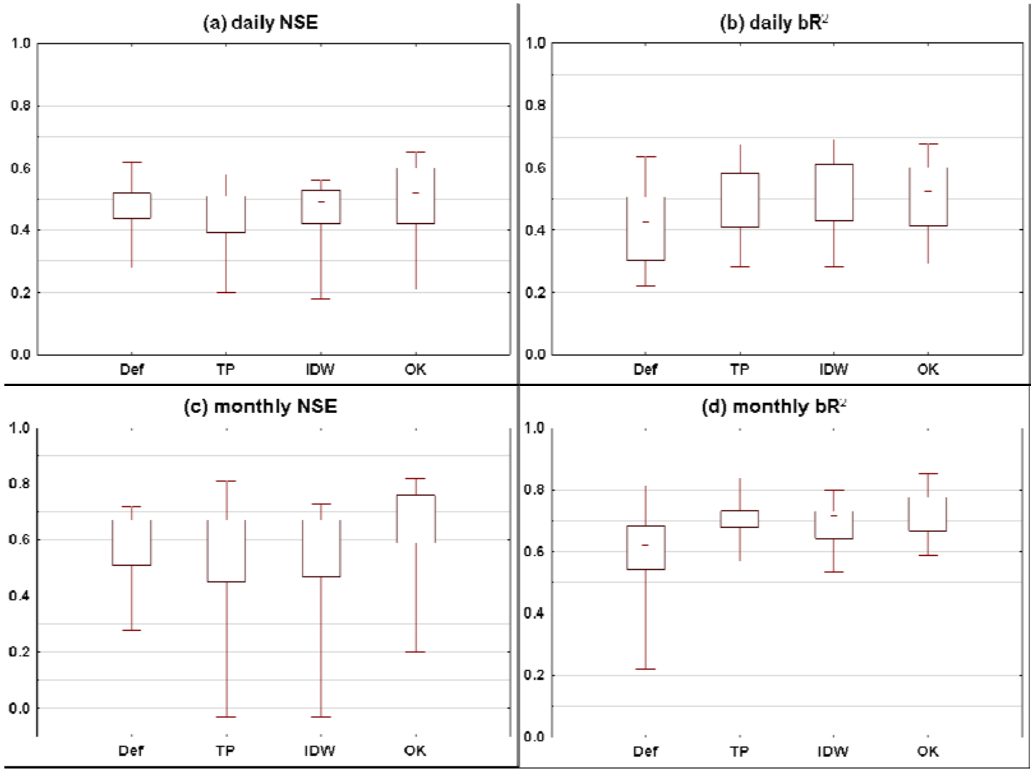
Example daily
precipitation
a – Def
b – TP
c – IDW
d - OK

SUFI-2 „calibration” parameters

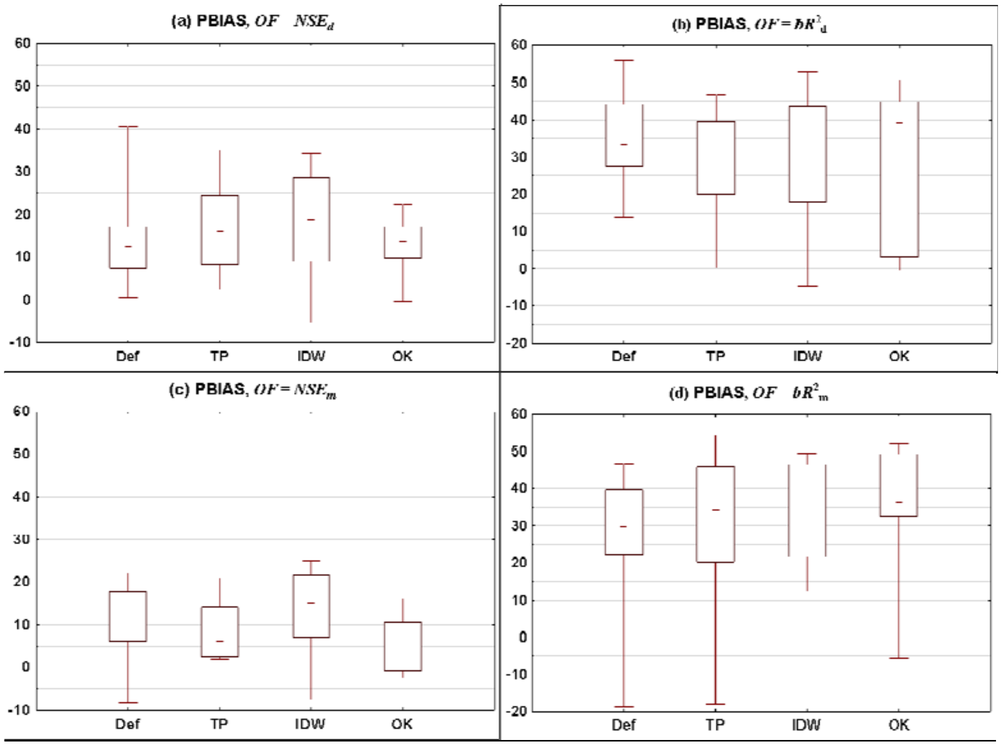
Name	Lower limit	Upper limit	Definition
ESCO.hru[2]	0.7	1	Soil evaporation compensation factor
EPCO.hru[2]	0	1	Plant uptake compensation factor
SOL_Z().sol[1]	-0.4	0.4	Depth from soil surface to the bottom of layer
SOL_AWC().sol[1]	-0.4	0.4	Available water capacity of the soil layer
SOL_BD().sol[1]	-0.4	0.4	Moist bulk density
SOL_K().sol[1]	-0.9	2	Saturated hydraulic conductivity
HRU_SLP.hru[1]	-0.3	0.3	Average slope steepness
ALPHA_BF.gw[2]	-0.9	2	Baseflow alpha factor
GW_DELAY.gw[2]	50	400	Groundwater delay time
GWQMN.gw[2]	0	1000	Threshold depth of water in the shallow aquifer required for return flow to occur
GW_REVAP.gw[2]	0.02	0.2	Groundwater "revap" coefficient
RCHRG_DP.gw[2]	0	0.3	Deep aquifer percolation fraction
CN2.mgt[1]	-0.15	0.15	Initial SCS runoff curve nr for moisture condition II
SURLAG.bsn[2]	0.3	3	Surface runoff lag coefficient
SLSUBBSN.hru[1]	-0.3	0.3	Average slope length (m)
CH_N2.rte[2]	0.01	0.1	Manning's "n" value for the main channel
CH_N1.sub[2]	0.01	0.1	Manning's "n" value for the tributary channel (-)
SMTMP.bsn[2]	-2	2	Snow melt base temperature
TIMP.bsn[2]	0	1	Snow pack temperature lag factor
SNOCOVMX.bsn[2]	0	40	Minimum snow water content that corresponds to 100% snow cover

Note: [1] parameter multiplied by 1+r, where r is a number between lower and upper limits, [2] parameter replaced by the new value from the range.

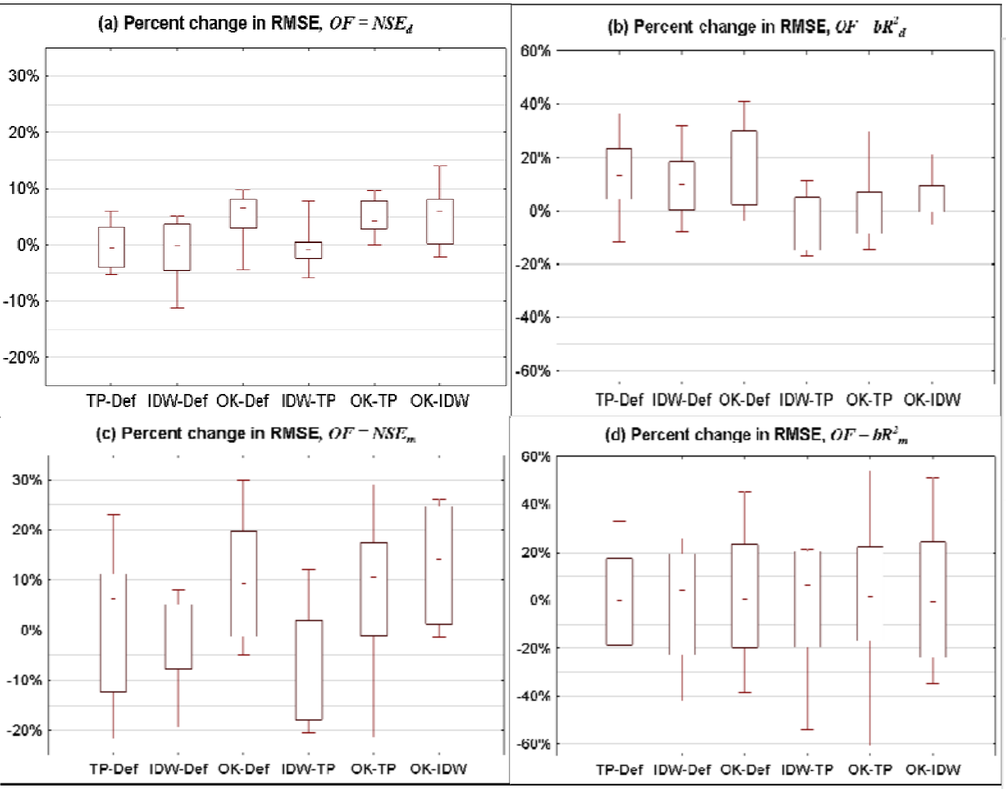
Results



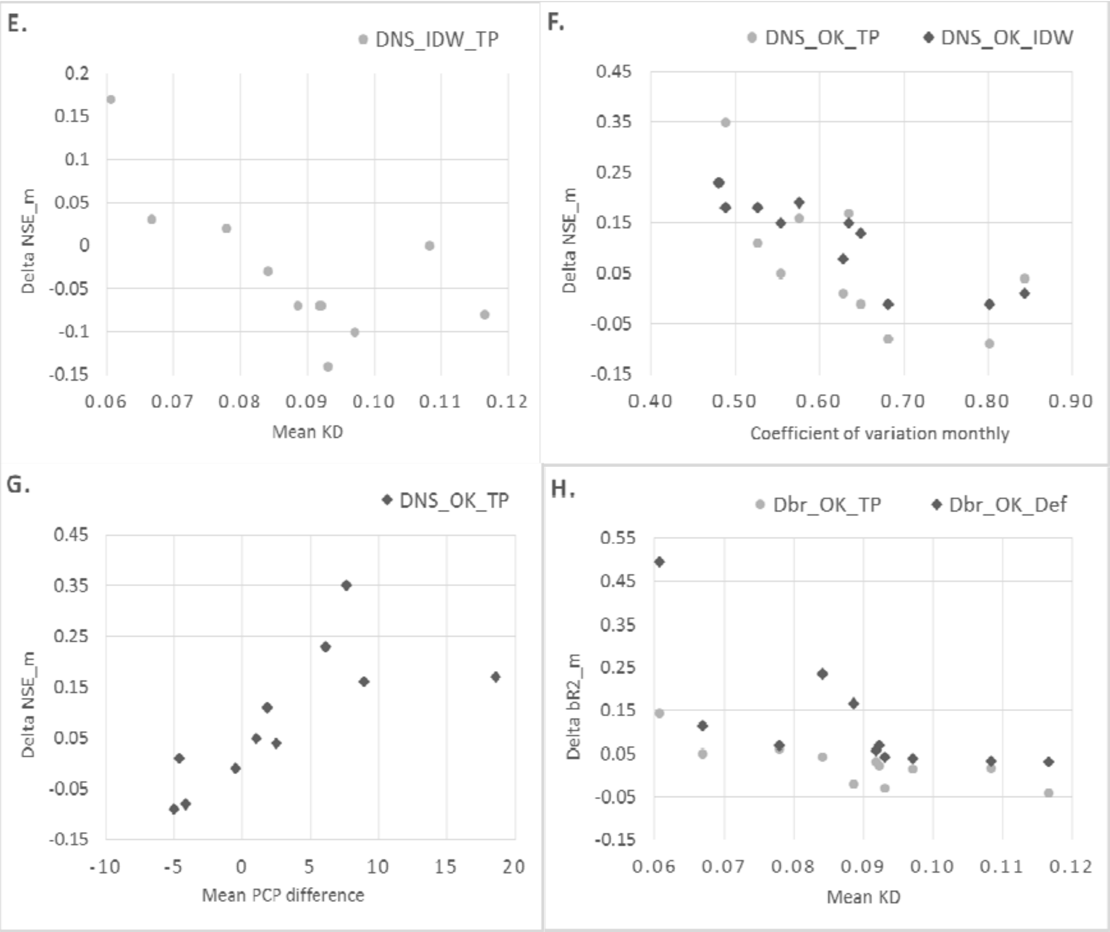
Box plots of selected objective functions across all 11 flow gauging stations for different interpolation methods (Def – Default version, TP – Thiessen Polygons, IDW – Inverse Distance Weighted, OK – Ordinary Kriging)



Box plots of PBIAS across all 11 flow gauging stations for different interpolation methods (Def – Default version, TP – Thiessen Polygons, IDW – Inverse Distance Weighted, OK – Ordinary Kriging) and different objective function / temporal aggregation combinations (A – NSE_d, B - bR_d^2, C - NSE_m, D - bR_m^2).



Box plots of percent changes in RMSE across all 11 flow gauging stations for different interpolation methods (Def – Default version, TP – Thiessen Polygons, IDW – Inverse Distance Weighted, OK – Ordinary Kriging) and different objective function / temporal aggregation combinations (A – NSE_d, B, - bR^2_d, C - NSE_m, D - bR^2_m).



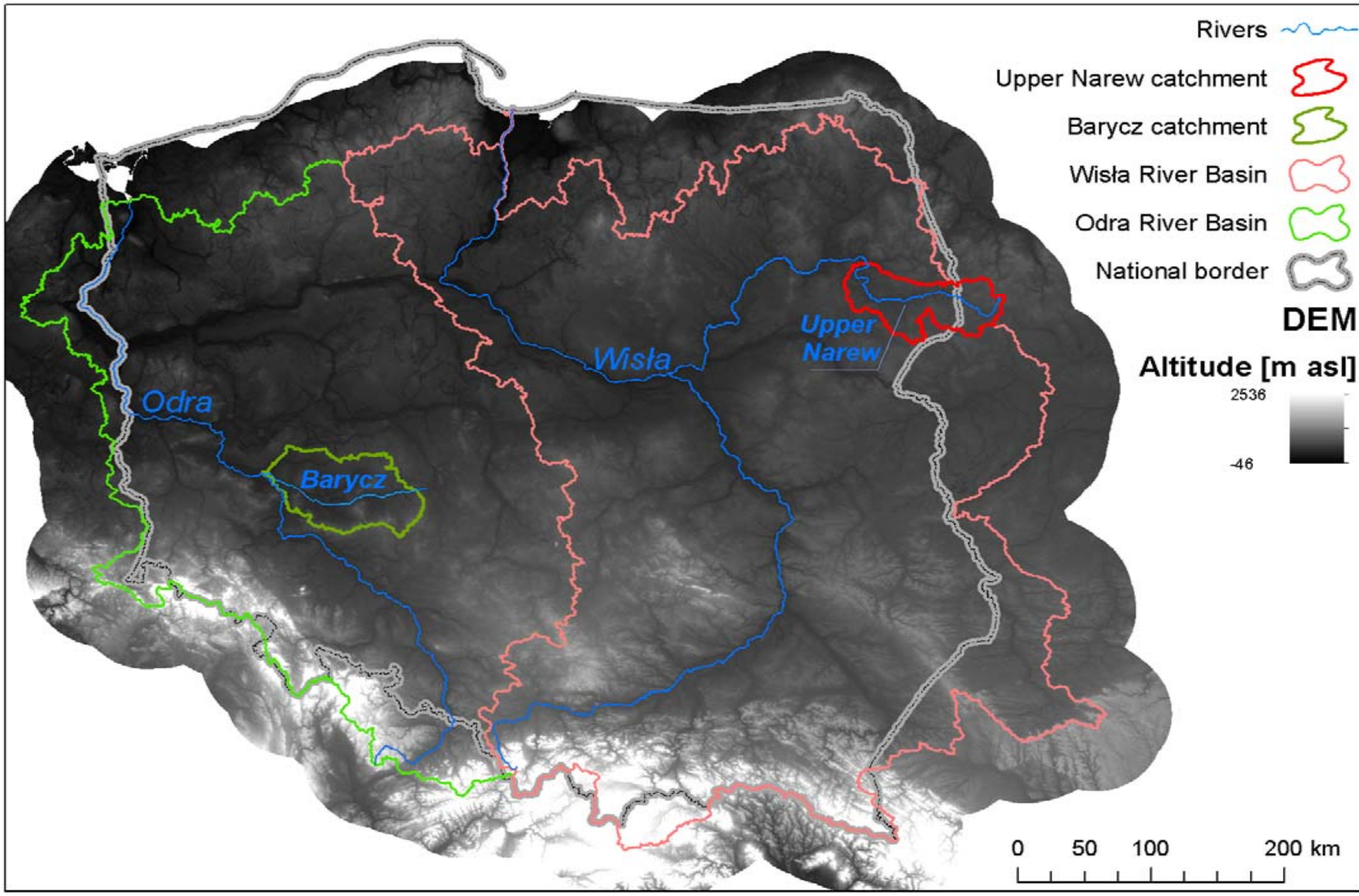
Scatter plots of changes in different obbjective functions and various catchment descriptors for relationships with significant correlation (at significance level $p = 0.05$)

Conclusions from Sulejów Case

- the most complex OK method outperformed other methods in terms of NSE, whereas OK, IDW and TP outperformed Def in terms of bR^2, regardless of temporal aggregation
- The difference between TP, IDW, OK and Def was spatially variable. Part of this variability was attributed to catchment properties.
- Spatial interpolation can improve the model simulations however various methods should be tested as the results tend to be catchment-specific.

Vistula and Odra Basins

- Part of the ongoing CHASE-PL project
- Vistula River basin – area 194 · 10^3 km^2
- Odra River basin – area 119 · 10^3 km^2
- Vistula – the 2nd largest river basin in EU, Odra the 5th

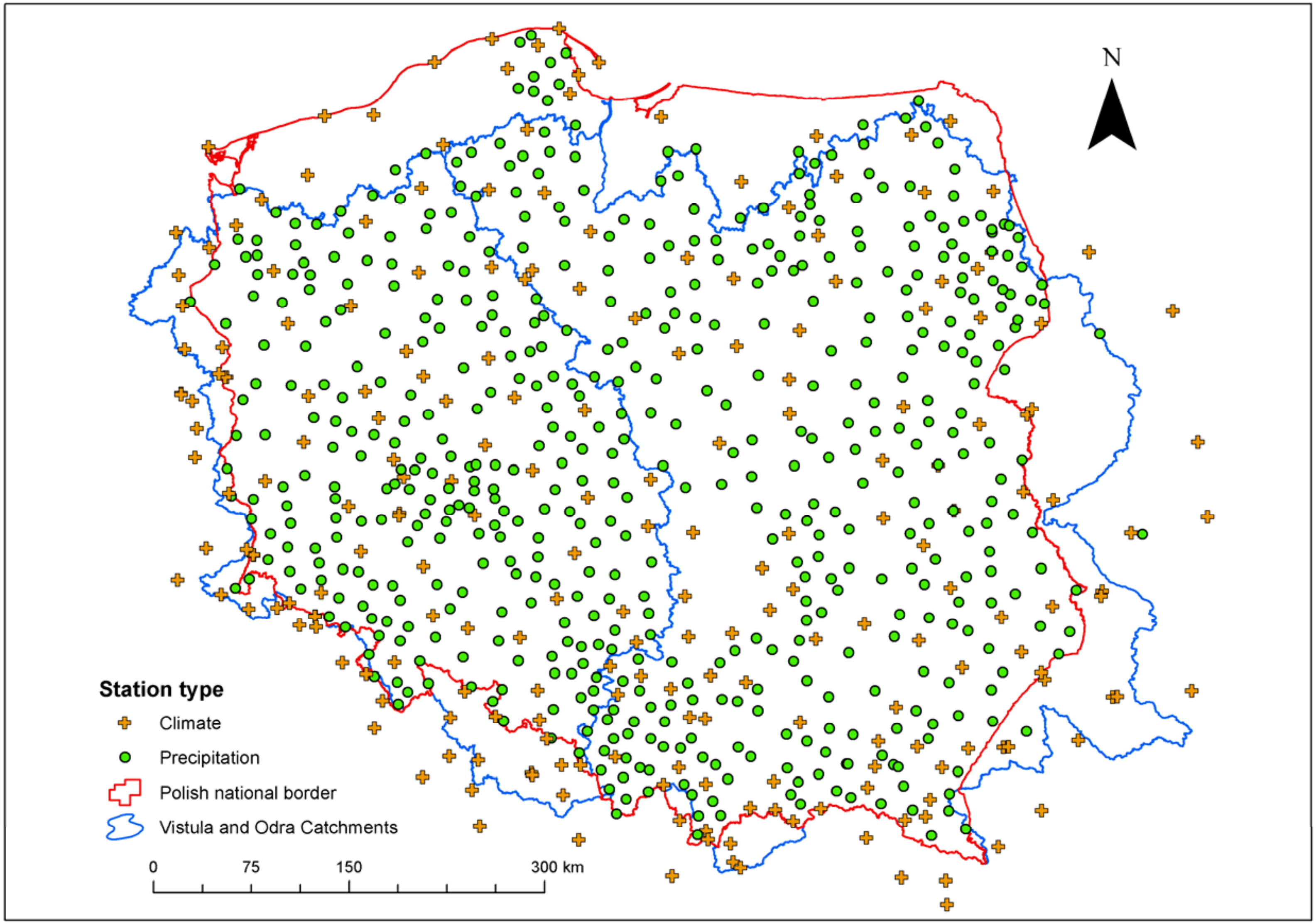


Vistula and Odra: 2nd and 5th largest river basins in EU

Development of gridded temperature and precipitation datasets for modelling - overview

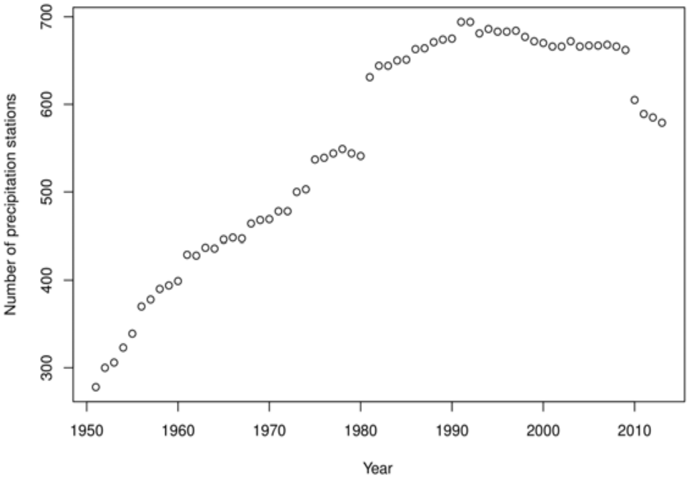
Item	Minimum and maximum temperature	Precipitation
Domain	Poland + Vistula and Odra basins	
Data sources	• IMGW-PIB – Polish stations • DWD - German and Czech stations • ECAD, NOAA-NCDC – Slovak, Ukrainian and Belarusian stations	
Preprocessing	Quality assessment	**Quality assessment** **Richter correction for precipitation undercatch**
Interpolation method	Kriging with elevation as external drift	**Combination of Universal Kriging and Indicator Kriging (for wet day probability estimation)**
Library	R gstat	
Time frame	1951-2013	
Resolution	5 km grid in the projected coordinate system PUWG1992	
Output format	.tiff files (one file per variable per day)	
Cross validation	All stations, for each day. Both temporal and spatial scale	
SWAT input	Aggregation at subbasin level	

Temperature and precipitation stations network



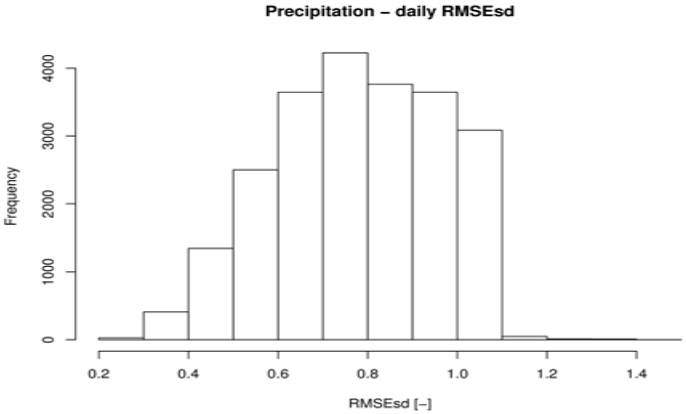
Annual variability of available data

Precipitation

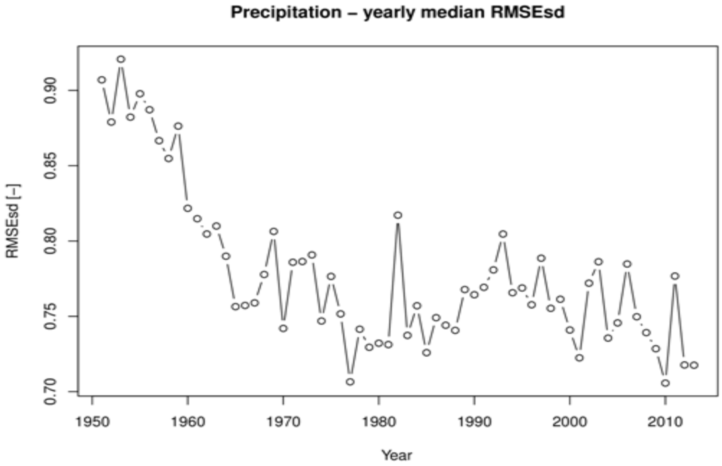


Range: 300-700

Cross validation results: standardized RMSE

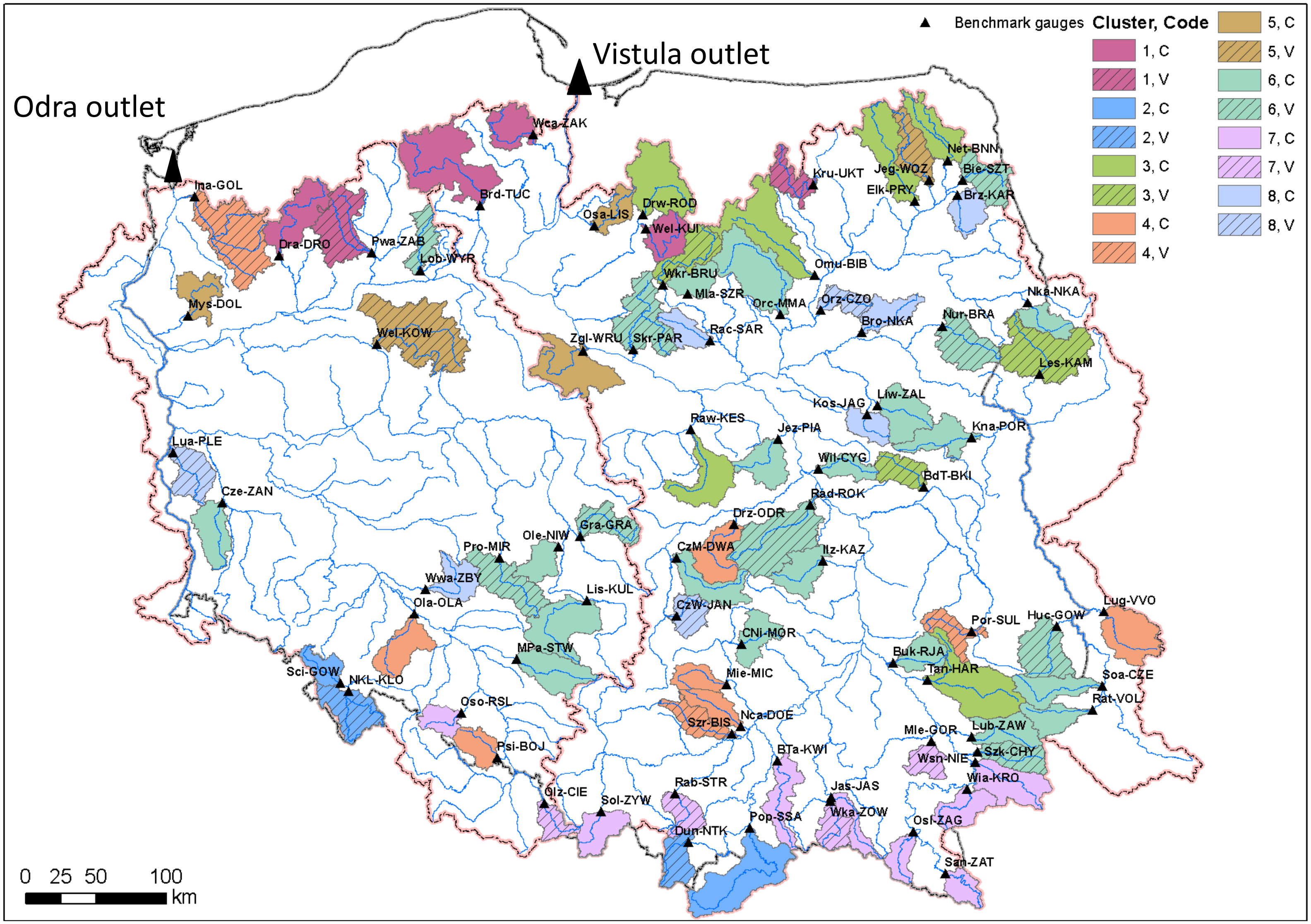


- Median range 0.7-0.8, with more than 85% of RMSE values not exceeding one standard deviation

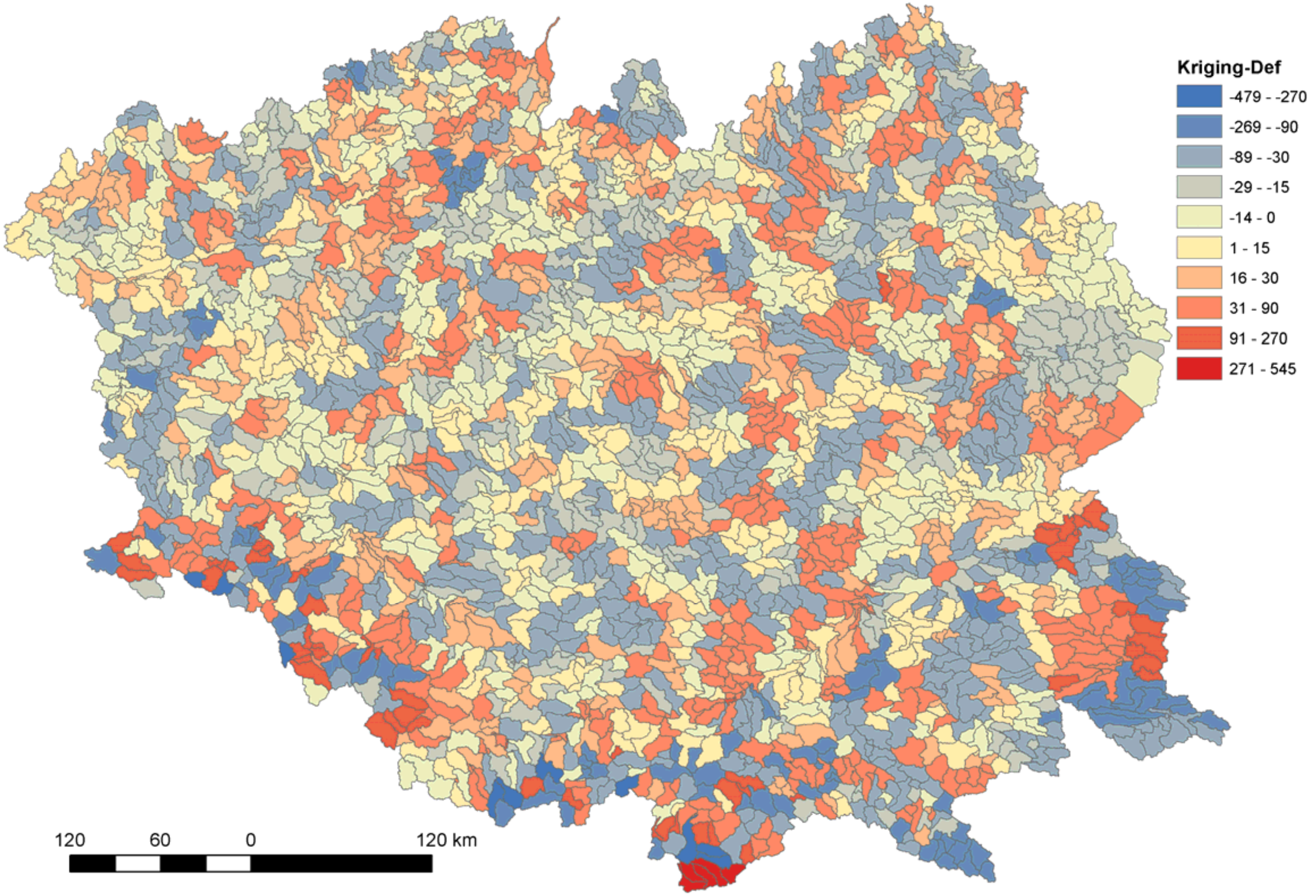


- Negative correlation with the numer of available stations
- Errors depend on the density of the observation network

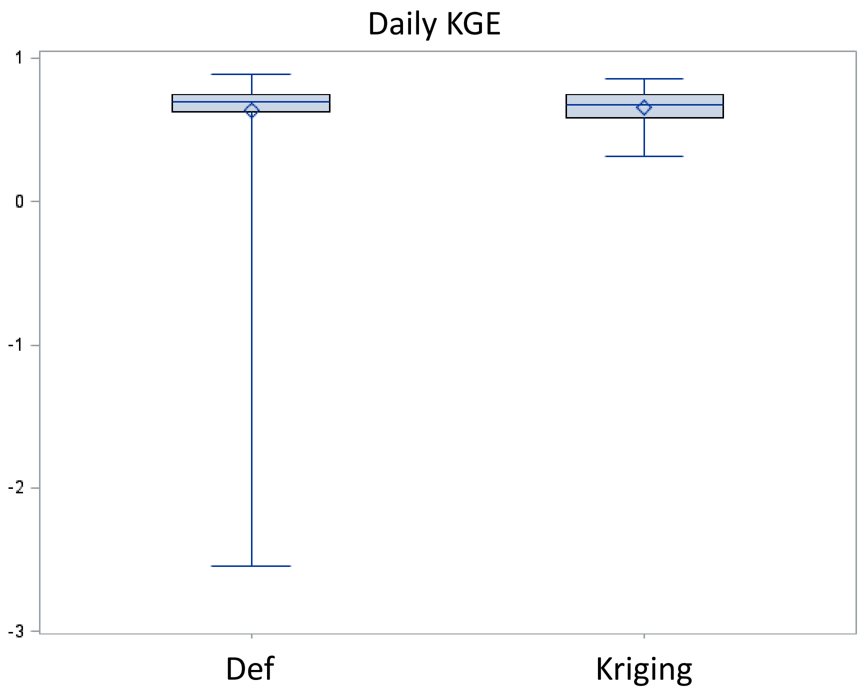
Catchments used in study



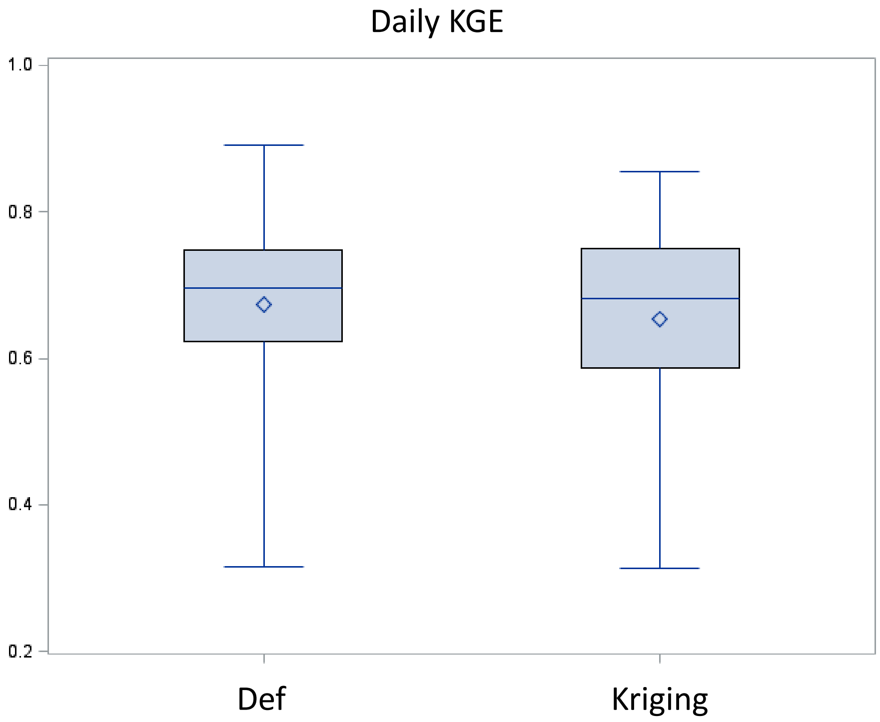
Mean yearly precipitation, years 1989-2000



Results



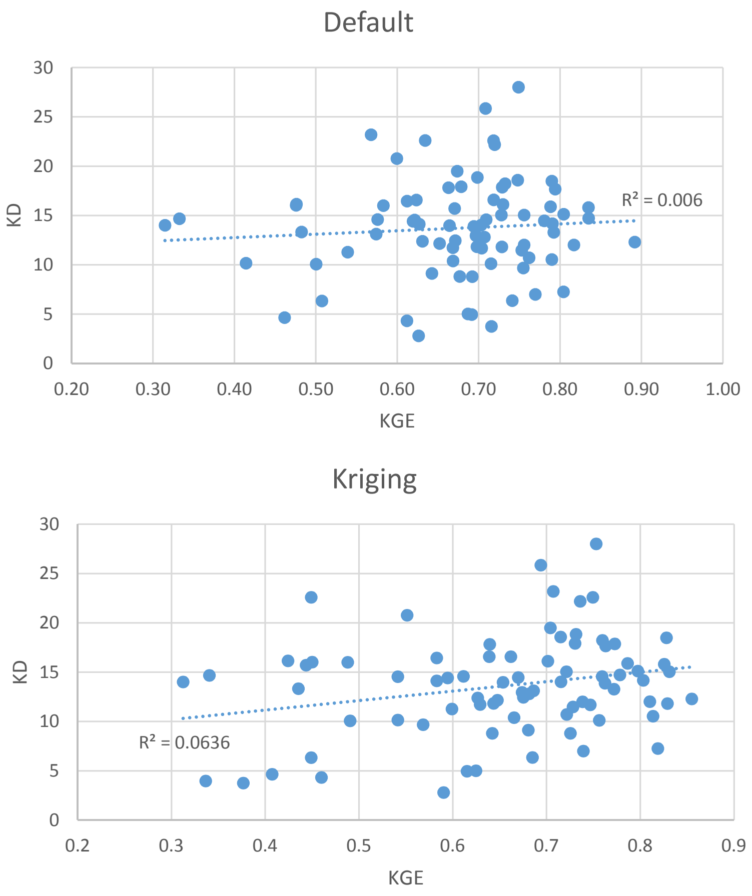
Box plot of KGE objective function across all 80 flow gauging stations for Default method – Def and Universal Kriging



Box plot of KGE objective function across all flow gauging stations (except Lug-VVO) for Default method – Def and Universal Kriging

KGE objective function for whole Vistula and Odra catchments

Gauge	KGE Default	KGE Kriging
Vistula outlet	0.71	0.76
Odra outlet	0.78	0.76



Scatter plots of KGE and Kernel Density

Conclusions from Vistula and Odra case

- Further investigation of the used interpolation method is needed