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Long-term ensemble forecast of snowmelt inflow into the Cheboksary Reservoir under two different weather scenarios

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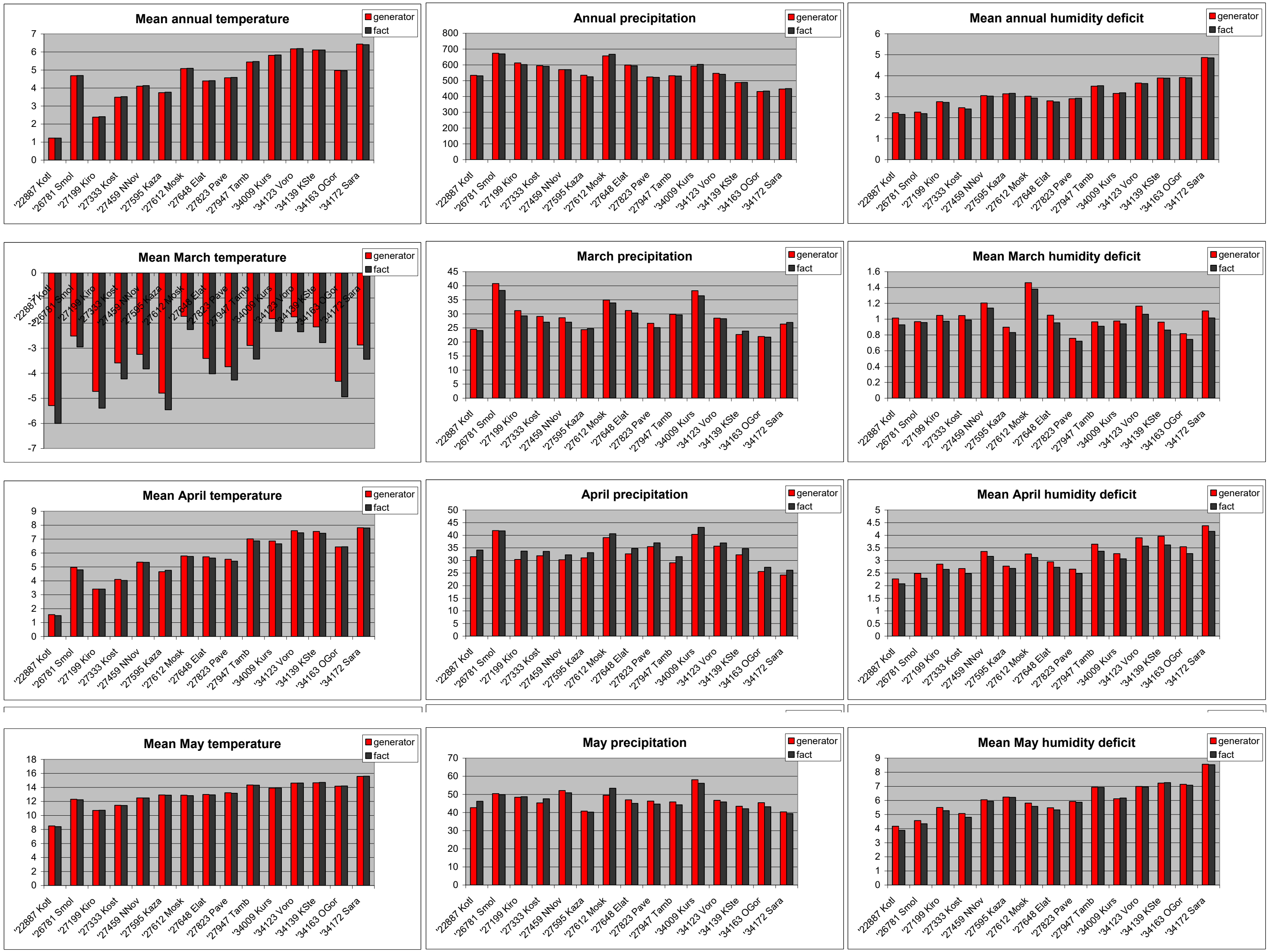


Fig. S1 ─ Annual and monthly mean values of air temperature (left column), precipitation (middle column) and air humidity deficit (right collumn). Black bars denote data derived from observations, red bars – simulations.

Fig. S2 ─ Coefficient of variation of annual and monthly values of air temperature (left column), precipitation (middle column) and air humidity deficit (right collumn). Black bars denote data derived from observations, red bars – simulations.

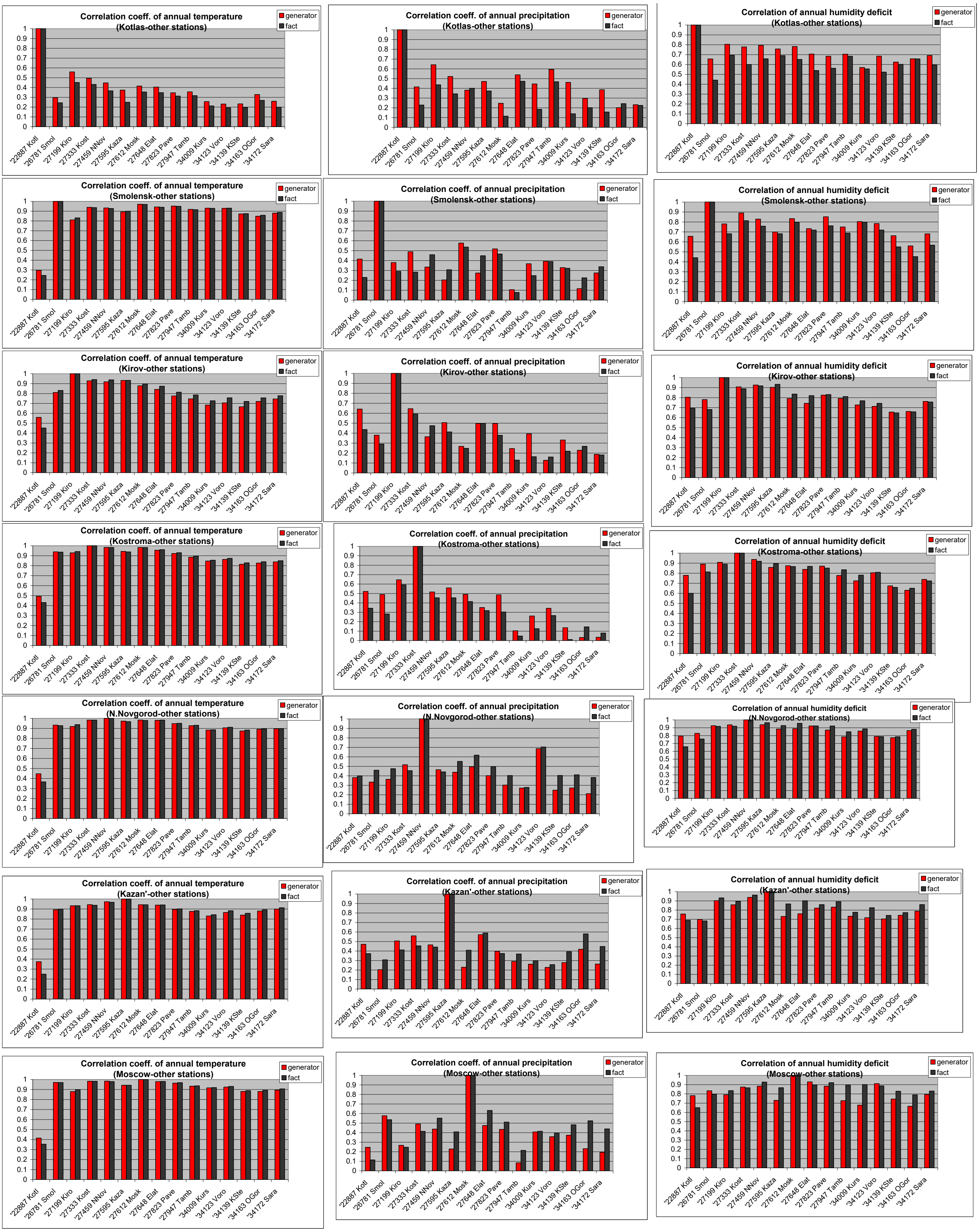


Fig. S3 – Pearson coefficient of correlation between annual air temperature (left column), precipitation (middle column) and air humidity deficit (right collumn) at different weather stations. Black bars denote data derived from observations, red bars – simulations.

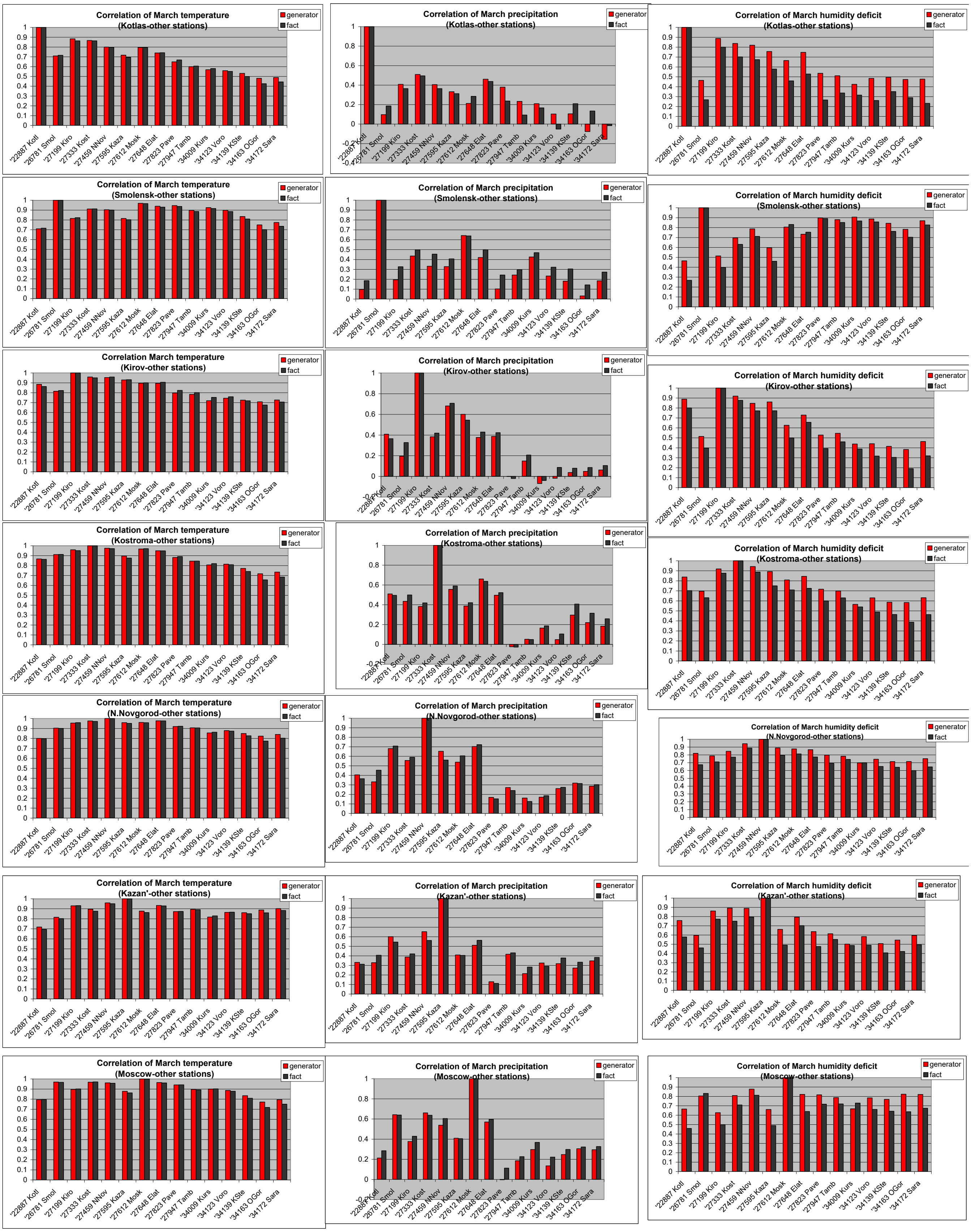


Fig. S4 – Pearson coefficient of correlation between March air temperature (left column), precipitation (middle column) and air humidity deficit (right collumn) at different weather stations. Black bars denote data derived from observations, red bars – simulations

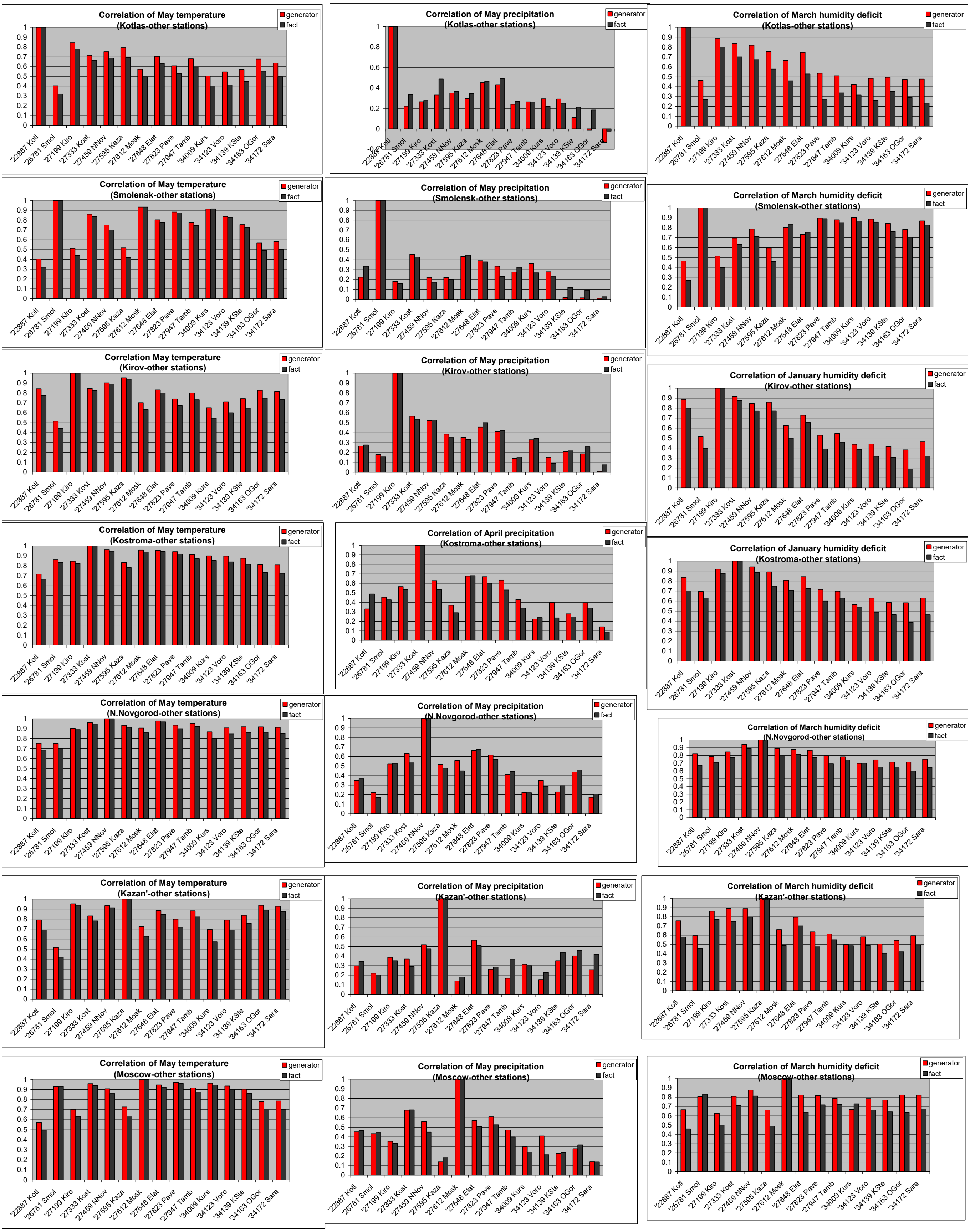


Fig. S5 ─ Pearson coefficient of correlation between May air temperature (left column), precipitation (middle column) and air humidity deficit (right collumn) at different weather stations. Black bars denote data derived from observations, red bars – simulations

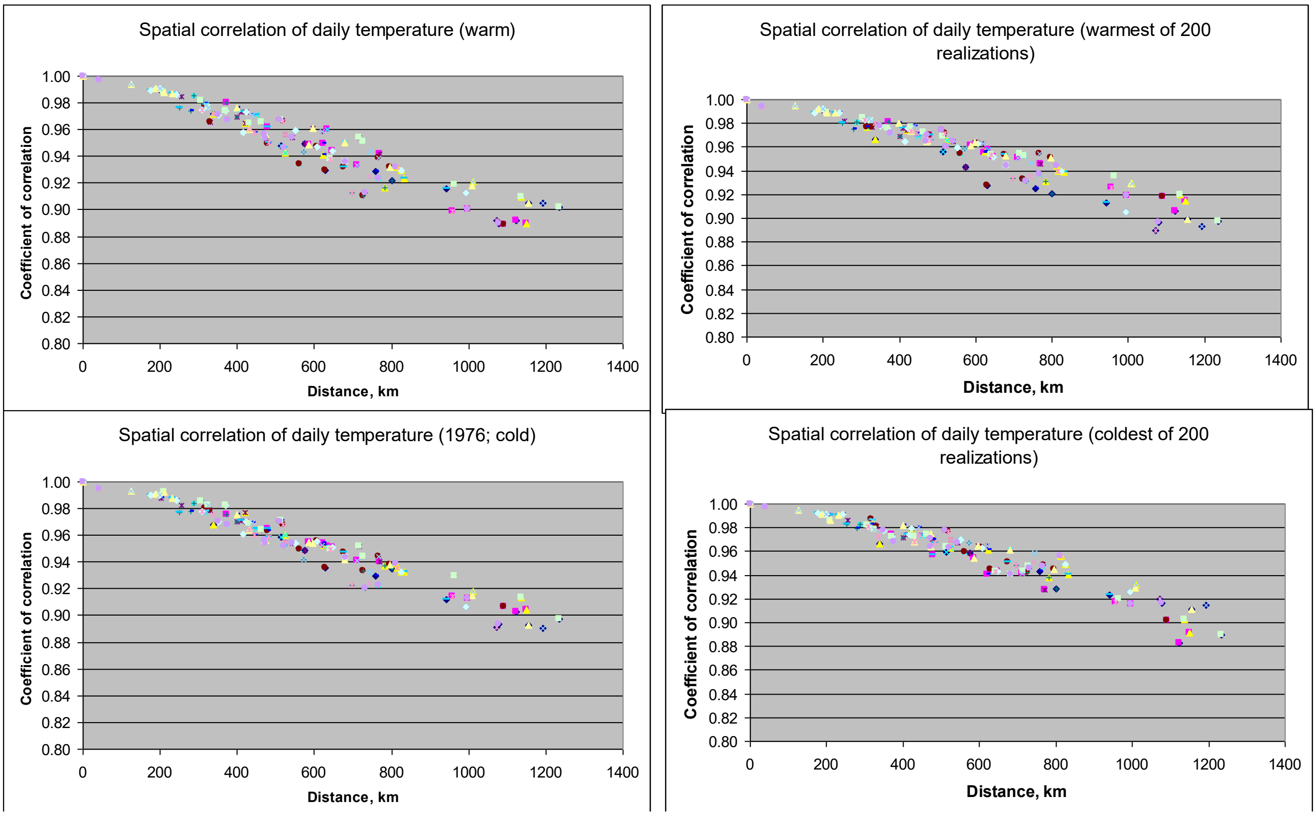


Fig. S6 — Spatial correlations of the observed (left) and generated (right) daily air temperature

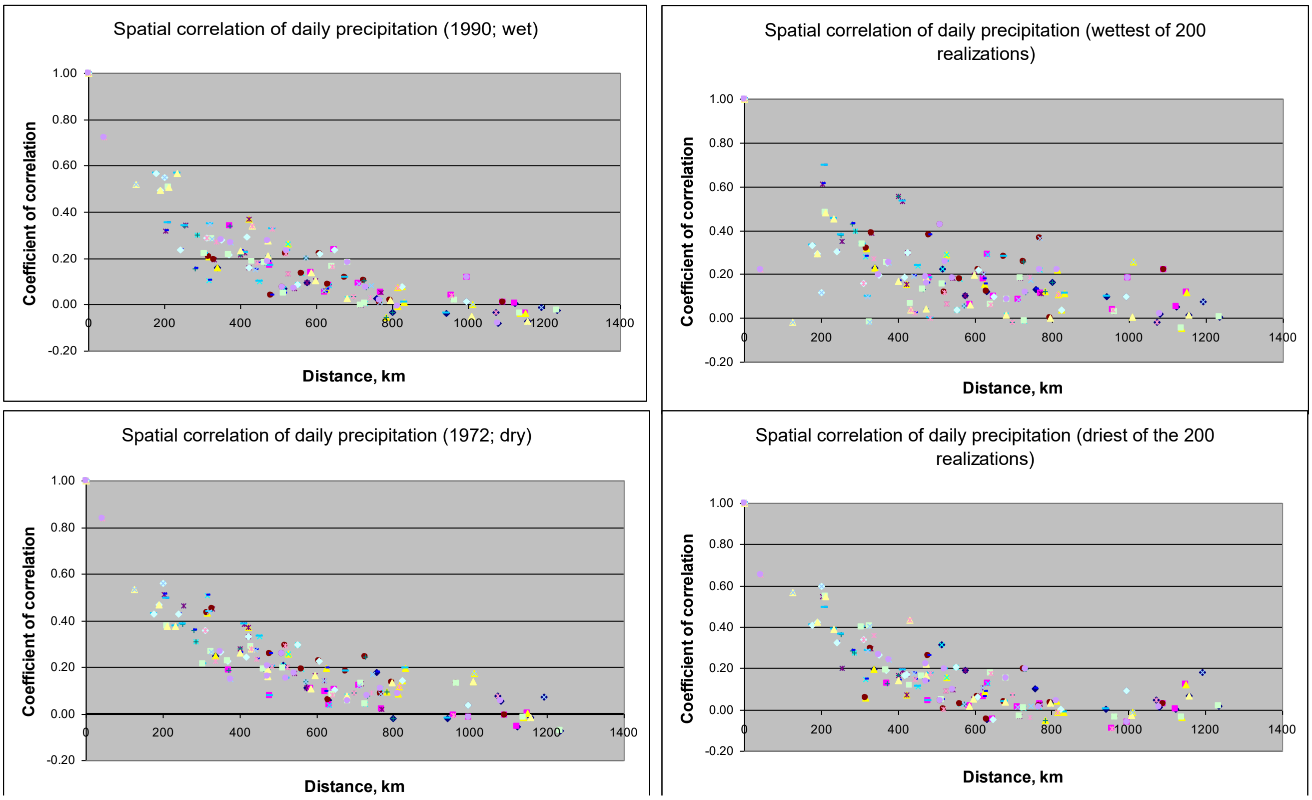


Fig. S7 — Spatial correlations of the observed (left) and generated (right) daily precipitation

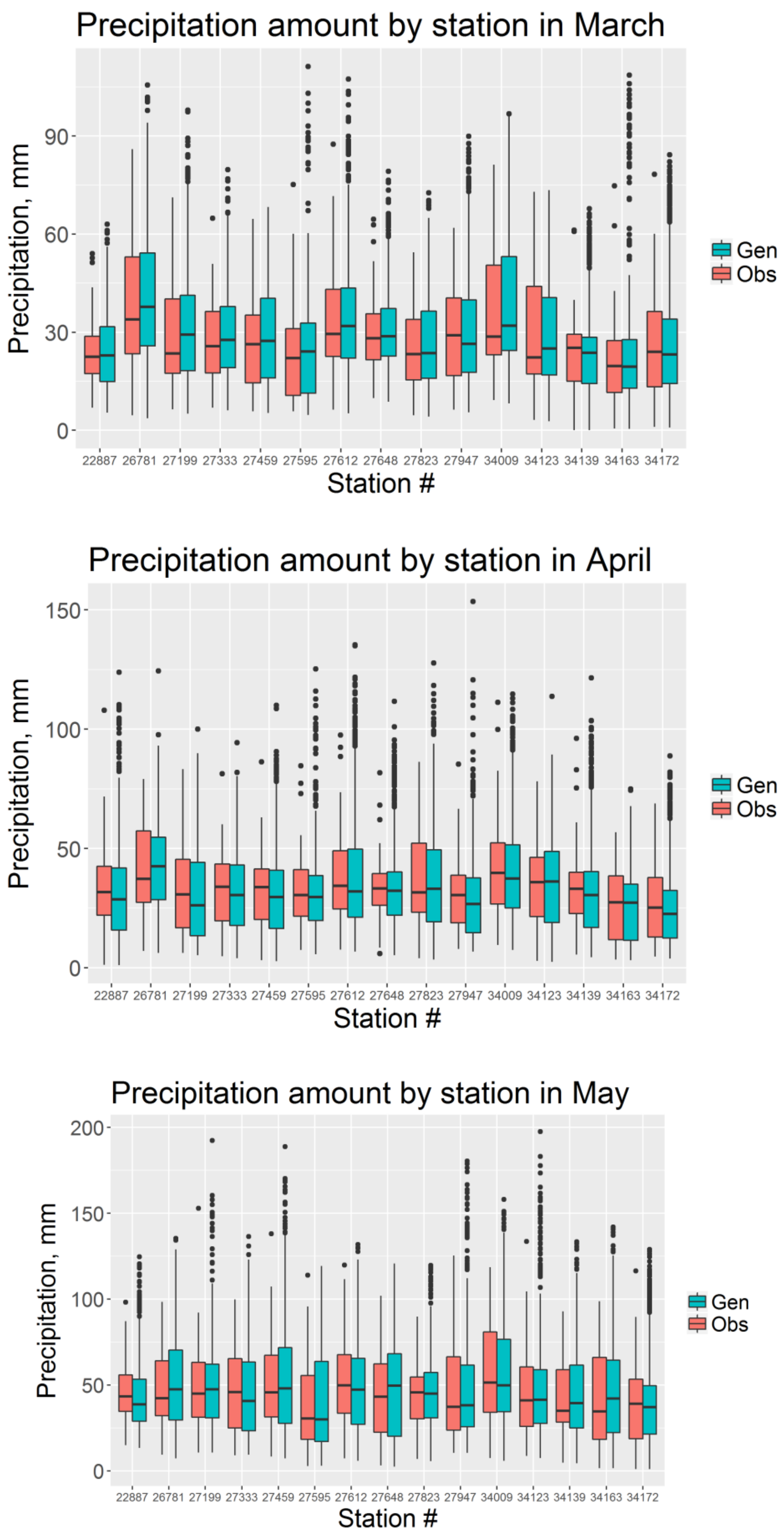


Fig. S8 –Box plots of monthly precipitation at different weather stations. Red boxes – observations; green boxes - simulations

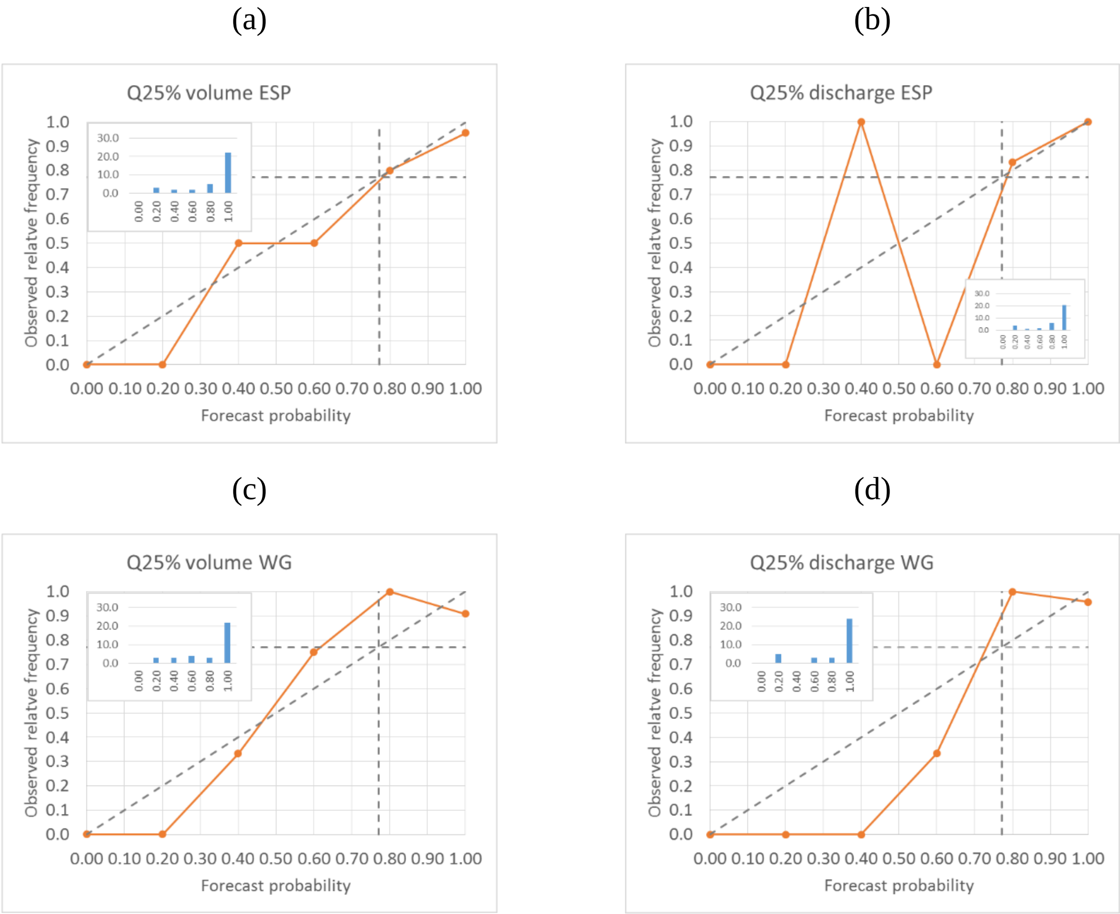


Fig. S9 – Reliability diagrams for ESP-based (a, b) and WG-based (c, d) forecasts of the 1st quartile of the inflow volume (a, c) and of the 1st quartile of the maximum inflow discharge (b, d)

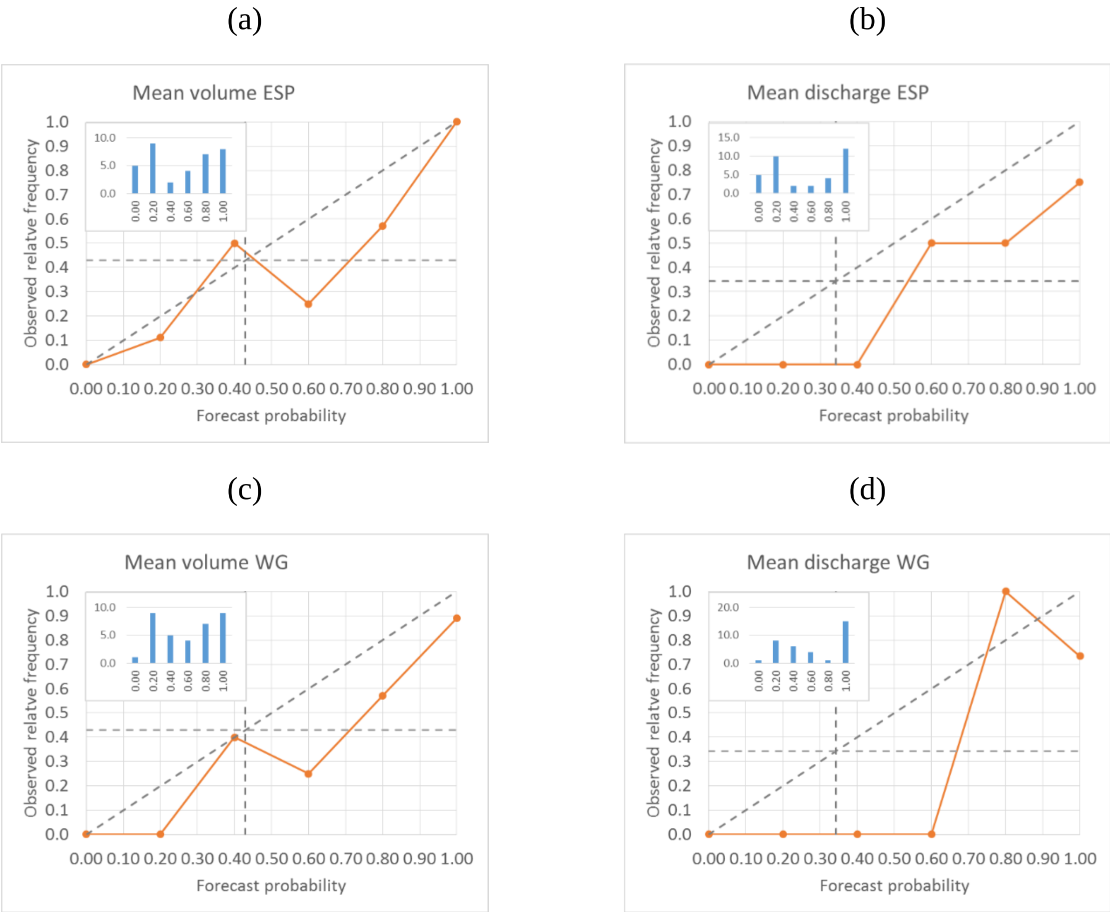
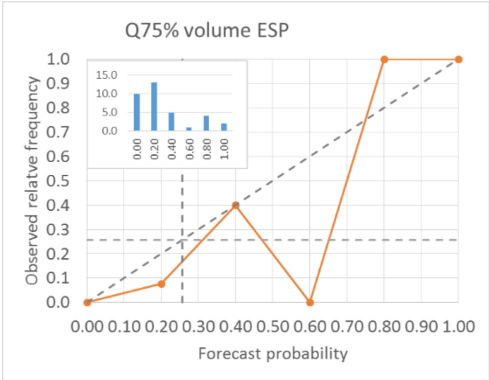
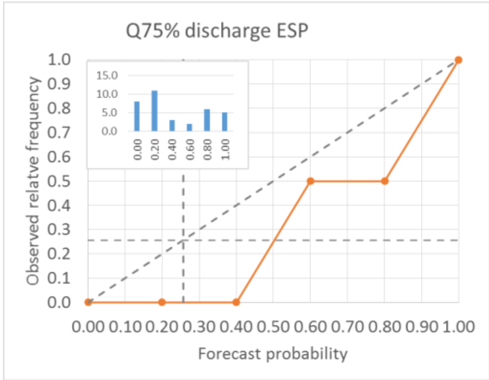


Fig. S10 – Reliability diagrams for ESP-based (a, b) and WG-based (c, d) forecasts of mean inflow volume (a, c) and mean maximum inflow discharge (b, d)

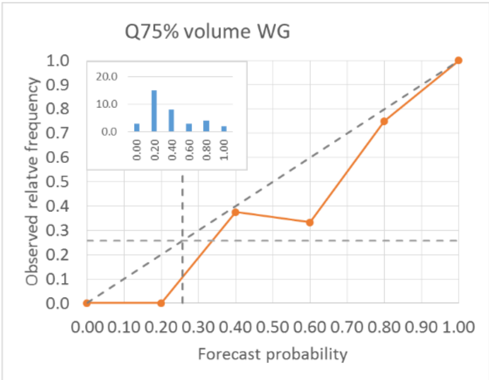
(a)



(b)



(c)



(d)

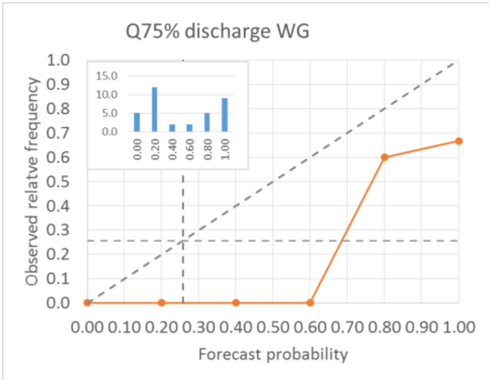


Fig. S11 – Reliability diagrams for ESP-based (a, b) and WG-based (c, d) forecasts of of the 3rd quartile of the inflow volume (a, c) and of the 3rd quartile of the maximum inflow discharge (b, d)

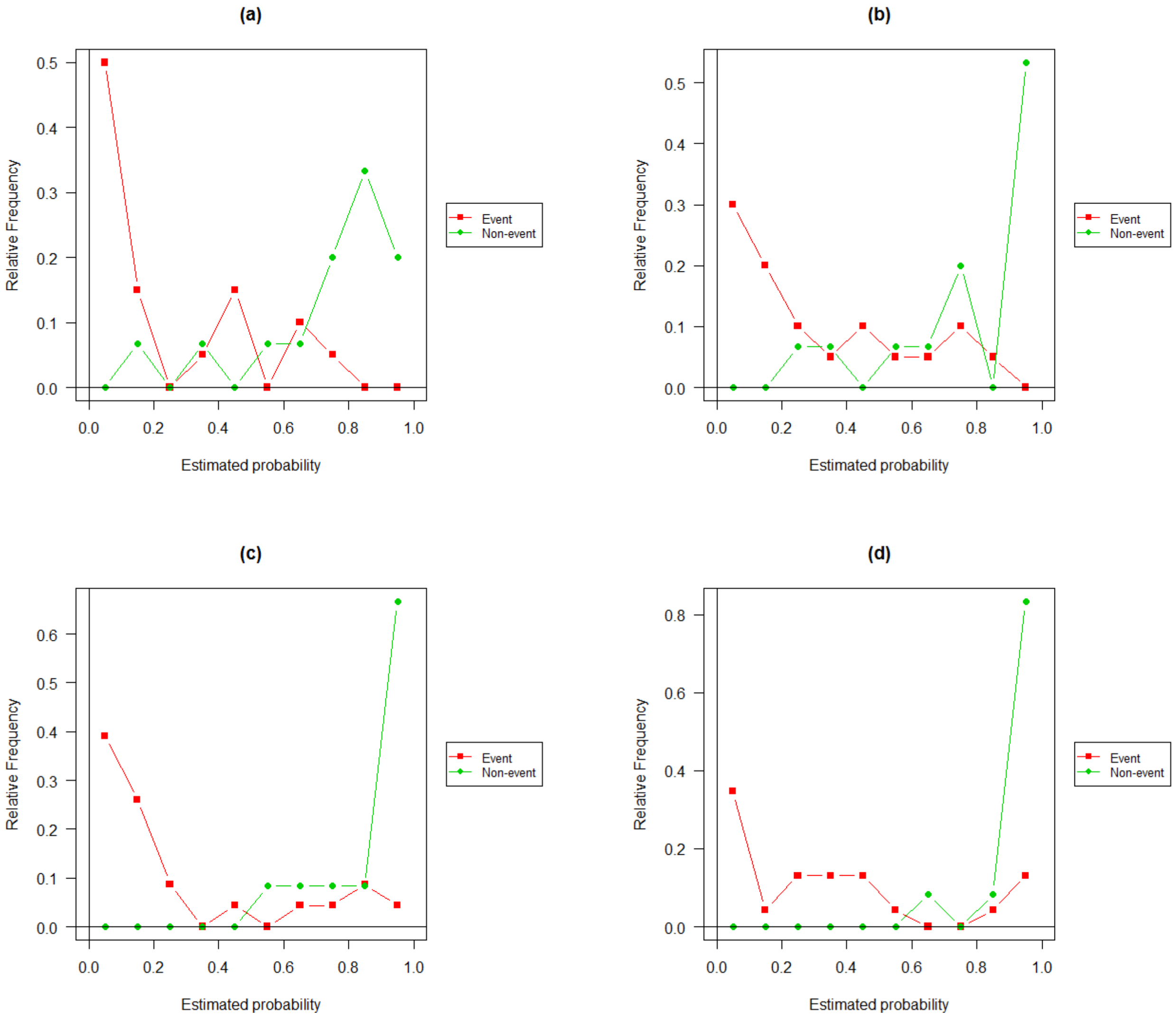


Fig. S12 – Discrimination plots of the ESP-based (a, c) and WG-based (b, d) forecasts of the mean annual volume (a, b) and mean maximum discharge (c, d) exceedance occurrence for in April – May

Table S1. List of the verification measures used

Metric	Symbol, abbreviation	Formulation	Unit, value range, perfect value	References
Model performance[1]				
Mean Error	ME	$ME = \frac{1}{N}\sum_{i=1}^{N}(x_i - y_i)$	Arbitrary, $(-\infty, +\infty)$, 0	Wilks, 1995
Relative bias	BIAS	$BIAS = \frac{\sum_{i=1}^{N} y_i - \sum_{i=1}^{N} x_i}{\sum_{i=1}^{N} x_i}$	%, $(-\infty, +\infty)$, 0	Wilks, 1995
Root mean square error	RMSE	$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - y_i)^2}$	Arbitrary, $(-\infty \div +\infty)$, 0	Wilks, 1995
Pearson's correlation coefficient	*R*	$R = \frac{\sum_{i=1}^{N}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{N}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{N}(y_i - \bar{y})^2}}$	Dimensionless, [-1, 1], 1	-
Nash-Sutcliffe model efficiency criterion	NSE	$NSE = 1 - \frac{\sum_{i=1}^{N}(y_i - x_i)^2}{\sum_{i=1}^{N}(x_i - \bar{x})^2}$	Dimensionless, $(-\infty, 1]$, 1	Nash and Sutcliffe, 1970
Deterministic binary forecasts performance (binary contingency tables[2]**)**				

[1] here x_i – observed value, y_i – forecasted or predicted value, i = 1, …*N* – total sample size

Metric	Symbol, abbreviation	Formulation	Unit, value range, perfect value	References
Probability of detection (“What fraction of the observed events were correctly forecast?”)	POD	$$POD = \frac{a}{a+b}$$	Dimensionless, $[0, 1]$, 1	Wilks, 1995
False alarm ratio (“What fraction of the predicted events actually did not occur?”)	FAR	$$FAR = \frac{c}{a+c}$$	Dimensionless, $[0, 1]$, 0	Wilks, 1995
Frequency Bias (“How did the forecast frequency of the events compare to the observed frequency of the events?”)	FBIAS	$$FBIAS = \frac{a+c}{a+b}$$	Dimensionless, $[0, +\infty)$, 0	Wilks, 1995
Heidke skill score (“What was the accuracy of the forecast relative to that of random chance?”)	HSS	$$HSS = \frac{(a+d) - \frac{(a+b)(a+c)+(c+d)(b+d)}{N}}{N - \frac{(a+b)(a+c)+(c+d)(b+d)}{N}}$$	Dimensionless, $(-\infty, 1]$, 1	Stephenson, 2000
Hanssen and Kuipers score (“How well did the forecast separate the events from the "no" events?”)	KSS	$$KSS = \frac{a}{a+c} - \frac{b}{b+d}$$	Dimensionless, $[-1, 1]$, 1	Woodcock, 1976
Symmetrical extremal dependency index (evaluates the performance of the forecast of rare binary events)	SEDI	$$SEDI = \frac{\log\left(\frac{b}{b+d}\right) - \log\left(\frac{a}{a+c}\right) - \log\left(1-\frac{b}{b+d}\right) + \log\left(1-\frac{a}{a+c}\right)}{\log\left(\frac{b}{b+d}\right) + \log\left(\frac{a}{a+c}\right) + \log\left(1-\frac{b}{b+d}\right) + \log\left(1-\frac{a}{a+c}\right)}$$	Dimensionless, $[-1, 1]$, 1	Ferro and Stephenson, 2011

[2] here *a* – hits, *b* – misses, *c* – false alarms, *d* – correct rejections, *N* – same as above

Metric	Symbol, abbreviation	Formulation	Unit, value range, perfect value	References
Probabilistic forecasts performance[3]				
Reliability diagram	-	Plotting the forecast probability against relative frequency of the observations in the corresponding forecast's probability bin	Both axis [0, 1], prefect forecast lies on 1:1 line	Hartmann et al., 2002
Discrimination plot	-	Plotting the frequency of each forecast probability for events and non-events	Both axis [0, 1], distribution of both forecasts should not overlap	Wilks, 1995
Predictive QQ-plot	-	Plotting the cumulative distribution of z against the cumulative uniform distribution, where $z_t = \frac{\sum_{i=1}^{N} \chi_i}{n}, \chi_i = \begin{cases} 1, y_t > \widehat{y_{t,i}} \\ 0, y_t < \widehat{y_{t,i}} \end{cases}$, $y_{t,i}$ is the predicted value at time t, y_t is the observed value, n is the number of values sampled from the predictive distribution	Both axis [0, 1], prefect forecast lies on 1:1 line	Laio and Tamea, 2007
Ranked probability score	RPS	$\overline{RPS} = \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{M}(f_i(m) - o_i(m))^2$	Dimensionless, $[0,1]$, 0	Wilks, 1995

[3] here f_i , o_i – forecast and observed probabilities within ith category, respectively $\bar{o}$ – climatological mean, m – probability bins; M – number of categories; N – number of the forecasted evemts

Metric	Symbol, abbreviation	Formulation	Unit, value range, perfect value	References
Ranked probability skill score (e.g. against climatology)	RPSS	$RPSS = 1 - \frac{\overline{RPS}}{\overline{RPS}_{ref}}$	Dimensionless, $(-\infty, 1]$, 1	Wilks, 1995

References to Table 1S

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Table S2 – List of the MSFR_WG parameters

	Parameter meaning	Parameter estimate
1	Spatially averaged annual mean of air temperature, ^{O}C	4.58
2	Spatially averaged annual mean of precipitation intensity, mm/day	1.52
3	Spatially averaged annual mean of air humidity deficit, mb	3.15
4	Standard deviation of spatially averaged annual air temperature, ^{O}C	0.99
5	Standard deviation of spatially averaged annual precipitation, mm/day	0.18
6	Standard deviation of spatially averaged annual air humidity deficit, mb	0.69
7	Pearson coefficient of correlation between spatially averaged annual temperature and precipitation	0.02
8	Pearson coefficient of correlation between spatially averaged annual air humidity deficit and precipitation	-0.51
9	Pearson coefficient of correlation between spatially averaged annual air humidity deficit and temperature	0.29