Appendix 2

Autoreferate in English

AUTOREFERATE

Krzysztof Kochanek

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Diplomas and scientific degrees

- **Master of Science, engineer**, graduated from the Department of Environmental Engineering, Warsaw University of Technology in 1997. I was supervised by Professor Marek Nawalany. I achieved excellent mark for the thesis and the dissertation defence.
- **Master of business administration**, graduated from Warsaw University of Technology Business School in 2000.
- **Doctor of technical sciences**, graduated from the Department of Environmental Engineering, Warsaw University of Technology in 2003. The title of the thesis was: '*The evaluation of the selected methods of water management decision making in the vicinity of open cast mines*', I was supervised by Professor Marek Nawalany. The thesis was reviewed by Professors Andrzej Kraszewski and Andrzej Sadurski. I achieved excellent mark for the thesis and the dissertation defence.

The employment in scientific institutions

- October 1997 – June 2003: PhD studies in the Institute of Environmental Engineering Systems. I giving lectures to the students on following subjects: Basics of Informatics (including programming and numerical methods), Basics of Systems Theory and Geographic Information Systems.
- Since January 2003: in the Department of Water Resources (currently Hydrology and Hydraulics) in the Institute of Geophysics (IGF) Polish Academy of Sciences as the assistant and, since October, as the assistant professor (*adiunkt*). In the IGF I joined the research team lead by Professor Witold G. Strupczewski.
- June 2007 – August 2008: 'post-doc' in the Centre for Water Resources Research, School of Architecture, Landscape and Civil Engineering, University College Dublin, Ireland, where I worked on the project '*Water Framework Directive, Integration, Negotiation and Communication of Optimal Measures with Stakeholders*' (WINCOMS). I was dealing with the decision making problems concerning the implementation of EU Water Framework Directive in Ireland.
- April 2010 – October 2011: in L'institut de recherche en sciences et technologies pour l'environnement « Cemagref » in Lyon, France, where I worked on the project: '*EXTreme RAinfall and FLOod estimation*' (ExtraFlo) and developed my knowledge on the frequency analysis of hydrological extreme phenomena in the context of flood modelling in French rivers.

Scientific achievements

a) The papers that constitute the basis of the application for the degree of *habilitated* doctor.

Floods are believed to be the most dangerous natural disasters in terms of number of casualties and hold infamous leading position in property damages. Consequently, the growing interest of the policy-makers and flood risk managers (e.g. European Directive of Assessment and Management of Floods, Directive 2007/60/EC), challenges the scientists to create a new generation of more accurate and reliable models, possibly taking into account estimation of the impact of environmental change on the flooding frequency. In addition, knowledge of the flood wave's parameters, in particular, the magnitude of the flood of certain return period, its volume and duration are key parameters used in the design of hydrological facility, preparing the procedures of protecting people and infrastructure against flooding and creating of envi-

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ronmental and water management policy in Poland and other countries. All these factors influence the intensification of the research on the issues of **Flood Frequency Analysis (FFA)**, which aims at increasing the reliability of hydrological models within the context of imperfect measurement series and change of the river regime.

Having almost completed my doctoral dissertation, at the beginning of 2003, I joined the project lead by prof. Witold G. Strupczewski at the Institute of Geophysics, and my attention was directed towards the issues of statistical modelling of the **Flood Frequency Analysis in a given cross-section of the river (so called: local analysis)**. This is the classical hydrological problem, whose importance has been increasing with the development of infrastructure, and which is still the subject of intensive research of scientists in Poland and abroad which can be confirmed by great variety of new papers published in recognized professional hydrological journals. Statistical models, thus, still form the basis of the workshop of hydrologists, designers and engineers of the hydrologic equipment, civil protection services, environmentalists and policy makers, despite considerable progress in the field of physical modelling and numerical methods.

The opportunity to co-operate with seasoned Polish and foreign authorities in hydrology: Professors W.G. Strupczewski (Institute of Geophysics, Polish Academy of Sciences), S. Węglarczyk (Cracow University of Technology), H.T. Mitosek (Jan Kochanowski University), V.P. Singh (Texas A & M University, USA), M. Lang (IRSTEA, France) and others, has stimulated the development of my experience in the subject of statistical modelling of flood events. My research interest mainly focused on the following issues:

- similarities and differences between physical and statistical flood models
- the accuracy of estimation of the quantiles with considerable return period (the so-called 'flood quantiles') by procedures combining the statistical models used in the hydrology and different methods of estimation of their parameters,
- robustness of methods of estimating of the statistical hydrological models parameters and quantiles on the imperfections of the largest elements in the sample
- proper selection of the best hydrological model fitted to a given sample,
- seasonal and annual approaches to maximum flows modelling
- flood frequency analysis in the non-stationary conditions

The results of my research on the **Flood Frequency Analysis (FFA) in a given river's cross-section** were presented in the **articles that constitute the basis of application for the degree of *habilitated* doctor**. The works are listed in chronological order of year of publication, from the oldest to the newest, with the specified number of points according to the list of *Ministry of Science and Higher Education* (MSHE), the five-year Impact Factor (IF) according to the *Web of Science*, and, where applicable, the number of citations by. *Web of Science* (WoS) and *Publish or Perish* (PoP):

(1) Strupczewski W.G., **Kochanek** K., Singh V.P. and Weglarczyk S. (2005) Are Parsimonious Flood Frequency Models More Reliable than the True Ones? I. Accuracy of Quantiles and Moments Estimation (AQME) – Method of Assessment. *Acta Geophysica Polonica*, Vol. 53, no 4, pp. 419-436

(2) **Kochanek** K., Strupczewski W.G., Singh V.P. and Weglarczyk S. (2005) Are Parsimonious Flood Frequency Models More Reliable than the True Ones? II. Comparative assessment of the performance of simple models versus the parent distribution. *Acta Geophysica Polonica*, Vol. 53, no 4, pp. 437-457. Cit. 5 times (PoP)

(3) Strupczewski W.G., **Kochanek** K., Weglarczyk S. and Singh V.P. (2005) On robustness of large quantile estimates of log-Gumbel and log-logistic distributions to largest element of the observation series: Monte Carlo results vs. first order approximation. *Stoch Environ Res Risk Assess*, Vol 19, No 4: 280–291, DOI 10.1007/s00477-005-0232-x. 27 points MSHE; IF: 1.211; cit. 1 time (WoS and PoP).

(4) Strupczewski W.G., Singh V.P., Weglarczyk S., **Kochanek** K., Mitosek H.T. (2006) Complementary aspects of linear flood routing modelling and flood frequency analysis. *Hydrol. Processes*,

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Vol. 20 (16), 30 October 2006, pp. 3535-3554. 32 points MSHE; IF: 2.599, cit. 5 times (WoS and PoP).

(5) Markiewicz I., Strupczewski W.G., **Kochanek** K., Singh, V.P. (2006) Relationships between three dispersion measures used in flood frequency analysis. *Stoch Environ Res Risk Assess* 20: 391–405 DOI 10.1007/s00477-006-0033-x. 27 points MSHE; IF: 1.211; cit. 3 times (WoS) and 6 times (PoP).

(6) Strupczewski W.G., Mitosek H.T., **Kochanek** K., Singh V.P. and Weglarczyk S. (2006) Probability of correct selection from lognormal and convective diffusion models based on the likelihood ratio. *Stoch Environ Res Risk Assess* (2006) 20: 152–163, DOI 10.1007/s00477-005-0030-5. 27 points MSHE; IF: 1.211; cit. 5 times (WoS) and 6 times (PoP).

(7) Strupczewski W.G., **Kochanek** K., Weglarczyk S., Singh V.P. (2007) On robustness of large quantile estimates to largest elements of the observation series. *Hydrol. Processes*. Vol. 21, issue 10, pp. 1328-1344. 32 points MSHE; IF: 2.559; cit. 1 time (WoS) and 2 times (PoP).

(8) Strupczewski W.G., **Kochanek** K., Singh V.P. (2007) On the informative value of the largest sample element of log-Gumbel distribution. *Acta Geophysica*, 55, 4, 652-678. DOI: 10.2478/s11600-007-0027-1. 13 points MSHE; IF: 1.000; cit. 1 time (PoP).

(9) **Kochanek** K., Strupczewski W.G., Singh V.P. & Weglarczyk S. (2008) The PWM large quantile estimates of heavy tailed distributions from samples deprived of their largest element. *Hydrological Sciences–Journal–des Sciences Hydrologiques*, 53(2), pp. 367–386. 32 points MSHE; IF: 1.891; cit. 2 times (WoS and PoP).

(10) Strupczewski W.G., **Kochanek** K., Feluch W., Bogdanowicz E. & Singh V.P. (2009) On seasonal approach to nonstationary flood frequency analysis. *Physics and Chemistry of the Earth* 34 pp 612–618. 27 points MSHE; IF: 1.211; cit. 2 times (WoS) and 1 time (PoP).

(11) Markiewicz I., Strupczewski W.G., **Kochanek** K. (2010) On accuracy of upper quantiles estimation. *Hydrology and Earth System Sciences*, Volume 14, Issue 11, 2010, Pages 2167-2175, DOI: 10.5194/hess-14-2167-2010. 32 points MSHE; IF: 2.967.

(12) Strupczewski W.G., **Kochanek** K., Markiewicz I., Bogdanowicz E., Weglarczyk S., Singh V.P. (2011) On the tails of distributions of annual peak flow. *Hydrology Research* Volume 42, Issue 2-3, 2011, pp. 171-192, DOI: 10.2166/nh.2011.062. 20 points MSHE; IF: 1.024. Cit. 1 time (PoP).

(13) Strupczewski W.G., **Kochanek** K., Bogdanowicz E., Markiewicz I., (2011) On seasonal approach to flood frequency modelling. Part I: Two-component distribution revisited. *Hydrological Processes*, article published 'on-line first', DOI: 10.1002/hyp.8179. 32 points MSHE; IF: 2.559

(14) **Kochanek** K., Strupczewski W.G., Bogdanowicz E. (2011) On seasonal approach to flood frequency modelling. Part II: Flood frequency analysis of Polish rivers. *Hydrological Processes*, article published 'on-line first', DOI: 10.1002/hyp.8178. 32 points MSHE; IF: 2.559

b) The description of the papers that constitute the basis of the application for the degree of *habilitated* doctor.

The papers are discussed in the logical order, not chronological of the publication, and to ease their identification, the numbers corresponding to the points listed above are indicated on the margins of the paragraphs.

(4) At the beginning of my research on the issues of flood frequency analysis (FFA) I joined the project on similarities and differences between the two approaches to flood modelling, i.e. by means of deterministic linear transformation models and statistical models of flood frequency in the context of the systematic error of flood quantiles estimates stemming from erroneous assumption of the probability distribution (model) and the natural imperfections of the measurement series (a small sample and the quality of the measured values). The first results of this work were presented at the 2003 symposium on *'Local and regional estimation of extreme Hydrological events'* in Lyon, and (in the same year) as a poster at the European Geophysical Union conference in Nice. Then the problem of competitive deterministic and

statistical models was significantly broadened and published in the prestigious journal *Hydrological Processes* (Strupczewski W.G., Singh V.P., Weglarczyk S., **Kochanek** K, Mitosek H.T., 2006). The studies revealed that there is a formal similarity between the techniques of linear wave transformation and flood frequency, but it is impossible to indicate the conceptual link between these complementary approaches. It is because the phenomena of flood are of stochastic character, which is difficult to reconcile with the deterministic nature of wave transformation models.

Working on this article, of course, required much knowledge on hydrology, physics, statistics and hydrological phenomena. When I was involved in research on these issues, I dealt with FFA relatively shortly. Therefore, my personal contribution concerned mainly the designing and programming of the software, performing calculations and analysis of the results necessary to support theses stated in the article. I estimate the contribution to 10%.

(1) & (2) While working on the issues described in previous paragraphs, I became particularly interested in the estimation error in quantiles of big probability of non-exceedance (flood quantiles), depending on the model and estimation methods. In fact, these studies were to address the lack of precise criteria and guidelines for the selection of the best estimation procedure 'model/method of estimation' in order to solve the practical problem of estimating flood quantiles. The tangible result of research on this issue was the two-part article published in *Acta Geophysica Polonica* (Part 1: Strupczewski W.G., **Kochanek** K., Singh V.P. and Weglarczyk S., 2005, and Part 2: **Kochanek** K., Strupczewski W.G., Singh V.P. and Weglarczyk S., 2005). In these papers we focused on the accuracy of mapping of the 'right tail' of probability distribution functions (models) by means of the estimation procedures. The estimation accuracy criteria were bias (*B*) and mean square error (*MSE*). The objective was to determine the limits of usefulness and develop the guidelines on the applicability of the various procedures for model/method of estimation, depending on the regime of the river and sample size. The set of the models used in the FFA included two-parameter probability distribution functions (defined by the scale and shape parameters) and their three-parameter counterparts (additionally defined by the location parameter) and four- and five-parameter versions of the Wakeby distribution. It is worth mentioning that the research was focused on 'heavy-tailed' distribution functions (though, not only such models were involved), because nowadays in statistical hydrology such models are assumed to best describe the extreme phenomena. To estimate the model parameters three competing methods were applied: the maximum likelihood (MLM), moments (MOM) and linear moments (LMM). The study was carried out for samples generated from the Wakeby distribution represented by five sets of parameters, which means that in most cases the assumed population model was false.

Contrary to theoretical assumptions and the results available in the literature, our calculations showed that the systematic error of estimation of large quantiles is smaller in the case of two-parameter distributions than in their three-parameter counterparts, especially for small samples (sample size, $N < 50$), the MOM proved to be the most accurate in terms of bias among the three considered methods. The values of MSE practically disqualified theoretically more flexible three-parameter models in favour of the simpler two-parameter distributions.

The most important achievement of this study was to demonstrate that simple two-parameter models are more reliable and accurate at estimating flood quantiles than their three-parameter counterparts, especially when the hydrological sample is small (as it often happens in practice). This observation is particularly relevant to the practice of hydrological and hydraulic facilities design. The results showed also that it would be naïve to believe that only one procedure 'model/ estimation method' can be used to describe complex phenomena such as floods. On the other hand, in the papers the guidance was provided on what procedures work best in particular situations.

My personal contribution to both parts of the work was significant (first part of 40%, while the other 45%) – I took part in the work on the article at any stage and I wrote significant parts of the article. It is worth mentioning, that while working on an article I designed and developed the software package of more than 40 procedures 'model/estimation method' – *Accuracy of Quantiles and Moments Estimation* (AQME), I designed and made all the calculations, analysis and interpretation of results. The computer package I created is still being revised supplemented and completed with the new procedures (currently there are over 60 of them). Its numerous modifications helped me and my colleagues in other projects. This article was a milestone in my scientific career and designated paths of research that I have been following by now.

(3) One of these directions was the FFA models robustness to the largest elements in the measurement sample. Research on this topic is of great practical importance, since the peak discharges measured dur-

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ing large catastrophic floods are usually marred by the greatest uncertainty and their 'error' be can 'transposed' into the estimated quantile and, eventually, falsify the conclusions drawn from the calculations. On the other hand, the largest elements are believed to convey information which we care about most, that is, on the behaviour of the river during immense floods. Therefore, the mechanisms of the impact of the biggest elements on the modelling results should undergo the thorough analysis, in order enable using the information in the sample accurately and simultaneously minimise the estimation errors. In the first article of the series of papers dealing with this topic published in *Stochastic Environmental Research and Risk Assessment* (Strupczewski WG, **Kochanek** K., Weglarczyk S., and Singh, VP, 2005) we examined the robustness to the outliers of the flood quantiles estimated by means of two heavy-tailed distributions, i.e. log-Gumbel (LG) and the log-logistic (LL). The results of Monte Carlo (MC) simulations for sample with the outlier were compared to the sample where the outlier was removed, and then confronted with the results for the first order approximation representative sample. It is worth noting that the study was carried out for cases where the distribution of population in the sample was known. Analysis of the results of computer simulations showed that the MLM is the most robust to the outliers for big samples, whereas when the sample is small the MO method is much better. Results for the representative samples were similar to the ones of computer simulation, especially for small values of the coefficient of variation (CV) in the sample. This paper happened to be the preliminary work to further analysis of the problem of robustness of the FFA models to the largest sample elements.
I estimate my contribution to this article as significant (45%) at each stage of work. In particular, I collaborated in developing a concept of research, carried out the calculations and charts, analysed the results, formulated conclusions. I wrote also a significant part of the article.

(7) In order to generalise the conclusions formulated in the paper described previously, in the next article of the series published in *Hydrological Processes* (Strupczewski W.G., **Kochanek** K. ,Weglarczyk S., Singh V.P., 2007) the range of competing models was extended to 6 distribution functions bounded at zero and 2 unbounded ones that are used in hydrology. The criteria of accuracy for estimating quantiles by means of three methods (MLM, MOM and LMM) were the systematic errors (bias, B) and mean square error (MSE). The MC simulations were carried out for two variants: (1) the sample deprived by the largest element and (2) when an outlier was introduced to the sample. In addition, the research was supplemented by the case study of the maximum annual flows for the years 1921 – 1950 for a gauging station Tryncza on the river Wisłok as well as the asymptotic approach.
Technically, the results confirmed the conclusions of the first article of the cycle. The findings of the supremacy of the MLM (for large and asymptotic samples) and MOM (for small and medium) were representative also for other heavy-tailed probability distribution functions bounded on the left at zero (log-normal, gamma, Weibull , Pareto, etc.). While the unrestricted models (e.g. normal or Gumbel) obtain better robustness of quantile when they are estimated by means of the LMM. The MOM also proved to be more robust to the outliers. It is worth noting that the deprivation of the largest element in the sample does not always lead to a deterioration of the results in estimation of flood quantiles of heavy-tailed distributions, particularly when we use the LMM! This means that when we are not sure about the quality of the largest item in the real measurement series, it is better to skip it without compromising the quality of the estimators. This observation is of great practical importance, since the peak discharges, with the greatest uncertainty, may be omitted in the analysis without harming the quality of the results!
The scope of my contribution to the work in the creation of the article estimate as significant (30%) at each stage of work and was analogous to the contribution of the previously described publications.

(8) The unusual discovery described in the previous paragraphs was thoroughly examined and described in the next publication of the series published in *Acta Geophysica* (Strupczewski W.G., **Kochanek** K., Singh V.P., 2007). It primarily focuses on the informational value of the largest element in terms of potential losses or gains resulting from intentional (or not) skipping of this element in the estimation of flood quantiles. The heavy-tailed log-Gumbel distribution was selected for the tests while the main criteria of estimation accuracy of flood quantiles were the bias (B) and Root Mean Square Error ($RMSE$). The methods used for estimation were the MLM, MOM and the Probability Weighted Moments (PMW) whose simple linear combination are linear moments. This paper considers the possible practical cases represented by the four variants of the MC numerical experiment, in other words, the limiting value of the probability of non-exceedance of the quantile (F_T) was sought for which: (A) the RMSE value for the censored sample is minimal, (B) the value of B is minimal, (C) F_T value is estimated by means of a simple empirical formula for the probability plotting position and, finally, (D) when $F_T = 1$, i.e. by mistake

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we find the largest element invalid and it is removed from the measurement sample but the sample is treated as 'non-censored'.
The calculation results showed that each of the three considered estimation methods, in special cases, may lead to the improvement of the quality of estimation (reducing *B* and/or *RMSE*) when the measuring series was deprived the largest (and most uncertain) element (variants A, B and D). In the case of the PMW, however, this effect is the most evident because the results are improved both in terms of the estimation efficiency and reduced RMSE. What is more, the PWM proved to be most robust to fluctuations in the coefficient of variation (*CV*) and the probability of non-exceedance (*F*). This important fact triggers the popularisation of the PWM (and its direct derivative – the method of linear moments) among hydrologists, as resistant to outliers and, at the same time, simpler to use than the MLM.
I estimate the scope of my contribution in the article as significant (45%) at every part of work and it was analogous to the contribution of the previously mentioned publications.

(9) Unquestionably interesting properties of the method of probabilistic weighted moments (PWM) was then the subjected of thorough investigation which were described in the last article of the series on censored sample in hydrology and published in *Hydrological Science Journal* (**Kochanek** K., Strupczewski W.G., Singh V.P. & Weglarczyk S., 2008). In the study we considered two cases often encountered in practical situations: (a) where the largest element in the measurement sample is deliberately ignored and the sample is treated as censored, and (b) when the largest element is removed (by mistake) and the sample is treated as complete. In the experiments for (a) the log-Gumbel distribution censored on the right side was used, whose quantiles were estimated by PWM for the censored distribution function. In addition, in order to compare the results with the one of the previous article, experiments were performed similarly to the four variants A, B, C and D, and the corresponding limiting probabilities of non-exceedance (F_T) were analysed. The MC simulation experiments were complemented by the real-data case of the maximum annual peak flows (1940 - 1969) in the Warta River in Konin. The results confirmed the findings, that the removing of the largest element can improve the quality of estimation (variants A and D) provided the assumed model and method. In variant B the unbiased quantile estimator for the censored sample is even more effective than for the complete sample. Thus, in practical situations by using appropriate estimation techniques for censored samples, one can obtain better results than for the non-censored sample, but one has to bear in mind the cost of increased bias. To sum up, if we do not know the parent probability distribution of the historical series of measurements, which, in fact, always happens in practice, and we are not sure of the largest element in the sample, it is better to employ the PWM for censored samples to predict the flood.
I estimate my contribution in the article as significant (45%) at every part of the work: development and discussion of the paper issues, analysis of results and drawing conclusions.

(5) Despite a well-established position of the maximum likelihood method among the methods for estimating flood quantiles in hydrology, practitioners are still eager to use methods based on dispersion measures and in case of linear moments this preference has been even increasing. However, the variety of ways to identify these measures when their impact on the accuracy of the estimation results is unknown results in indecisiveness regarding the use of the technique to obtain the best estimate of extreme floods. This practical problem of excess tools directed my interest towards the on-going research project on the interdependence of scattering measurements used in hydrology. The clear relationship between measures of dispersion could lead to a reduction in the number of these measures and, consequently, to simplify the decision making process. In the paper published in *Stochastic Environmental Research and Risk Assessment* (Markiewicz I., Strupczewski W.G., **Kochanek** K., Singh V.P., 2006) the properties of three measures of dispersion were compared, namely: the standard deviation (SD), the mean deviation (MD) and the second linear moment (λ_2), and then formulae for their inter-relationship were derived for the two-parameter and three-parameter models most commonly used in FFA. It was not possible to show simple non-parametric relationships between the dispersion methods. To convert one measurement to another you need to know the probability distribution function (unbounded models – Gaussian, Gumbel), since the relationship between measures of dispersion for the model is constant. The models bounded on the left at zero (two-parameter gamma, Pareto, Weibull, GEV, log-normal, etc.) require additional knowledge of the coefficient of variation (*CV*), whereas in three-parameter models (with the parameter of location), the coefficient of skewness (*CS*) is needed. Apart of these, the accuracy of flood quantile estimators obtained by three methods based on the considered dispersion measures and their resistance to the largest elements in the sample was examined. The first competition was won by the SD, while in the

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latter the MD was the best method, surpassingly even better than the method based on linear moments. However, note that the results were obtained for cases of known distribution of the population the sample came from, which practically never happens in reality.
My contribution to the paper was significant (10%). In particular, I created some pieces of software used in the calculations; in addition, I focused on the problem of robustness of methods to the largest elements in the sample.

(6) While working on the accuracy of flood quantiles estimation procedures 'model/method of estimation' (articles 1 and 2) I realised that the output of this procedure strongly depends on the probability distribution function fitted to the measurement series. On the other hand, it is known that the true FFA model is not (and never will be) known, since nature is too complicated, so it could be described by simple mathematical models. Nevertheless, one can try to minimize errors resulting from improper use of the model by fitting the models that are as close to the sample as possible (within the available limits) with the help of the appropriate methods of models discrimination. In the paper considering the problem of proper selection of a model, published in *Stochastic Environmental Research and Risk Assessment* we examined the discrimination power of selected techniques based on the maximum likelihood method (Strupczewski W.G., Mitosek H.T., **Kochanek** K., Singh V.P. and Weglarczyk S., 2006). For the study the two probability distribution functions close to each other in shape and statistical properties were selected namely the log-normal (LN) and the convective-diffusion (CD). The aim of this study was to demonstrate that the use of discrimination techniques without the knowledge of their properties for the models similar to each other leads to wrong decisions on the selection and, consequently, to the underestimation of flood quantiles. In this work using MC simulations the probability of correct selection (PCS) of the model was estimated, i.e. the frequency of the selection of the LN model when the sample was generated from the LN or the CD when sample came from the CD generator. The experiments were carried out for different sample sizes and *CV*. Because of the similarity of models the low effectiveness of the discrimination procedures was expected, but surprisingly for the small samples the PCS for CD was *circa* twice as much as for LN. Moreover, the discrimination power of the PCS procedure rarely exceeded 50%! Therefore, the second supporting discrimination procedure developed by Queensbery and Kent (1982) was employed in this research. This technique proved to be slightly more efficient than the MLM procedure, but still unsatisfactory. The efficiency of both procedures is increasing, of course, with the sample size.
The main conclusion drawn from this work is the surprisingly low efficiency of the discrimination procedures for short measurement series. In practical situations, where the measurement sequences consist of at maximum 50-70 elements, in order to select the model, one should take advantage of several discrimination techniques to avoid wrong choices. On the other hand one should be aware that the selected model is only a simplification of reality and to estimate flood quantiles try to use methods that minimize the model error (i.e. the PMW and LMM).
My contribution to this publication was significant (20%), I took part in the work at every stage of work on article, I wrote substantial part of the article.

(10) The method of the alternative events promoted by the Polish Institute of Meteorology and Water Management, and the potential improvement of the quality of flood quantiles estimation triggered the research on this method which resulted in the series of articles on seasonal approach for estimation of the maximum annual flows. The first results of research on this issue were shown on the XXVIII International School of Hydraulics in 2008 (details of the paper in Appendix 3). A very important achievement in the light of ongoing climatic changes, was the generalisation of the seasonal approach to the cases of non-stationary seasonal measurement series (regardless of the origin of non-stationarity), but this non-stationarity is expressed in time-dependent moments – mean and standard deviation. At the workshop in Capri (2008) an original two-step (called also the '*combined method*') technique of estimating of trends in the mean and standard deviation by the weighted least square method (first stage) and the linear moments (second stage) was announced for the first time. As the result of the calculation of this method one obtains the time-dependent quantiles of assumed probability of non-exceedance. The two-step method competes with the classical technique based on the maximum likelihood estimation. The issue of non-stationary and two-season approach was considerably developed and the results were published in *Physics and Chemistry of the Earth* (Strupczewski W.G., **Kochanek** K., Feluch W., Bogdanowicz E. & Singh V.P., 2009). In this work we identified two series of the seasonal peak flows (for winter and summer) because the origins and nature of the extreme flows occurring in winter (mainly due to thaws) are differ-

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ent than in the summer (caused by heavy rains). In consequence, we hoped to obtain for the FFA twice as much more homogeneous data than we could have using only annual peak-flow series. The non-stationary seasonal approach is said to give more accurate estimators of the annual maximum quantiles (stationary and non-stationary) than the classical estimator based on the maximum annual flows. Of course, the flooding phenomena observed in Poland are the 'mixture' of summer and winter floods whose ratio changes with the time and river course. The method assumes that the seasonal sequences are independent and each season can be modelled by different probability distribution, so the maximum annual flood quantiles can be derived from the model which is the alternative of seasonal distribution functions. In the first part of the paper the Gumbel distribution was adopted as a seasonal model for both summer and winter, therefore, under certain assumptions, the annual distribution is also of the Gumbel form which simplifies the theoretical analysis. Basing on this model we could show that, in theory when there is no model error, an approach based on seasonal maxima (SM) gives more accurate estimators of annual flood quantiles than the classical model based on the annual maxima (AM). In the second part of the article the set of models was extended by a further 7 three-parameter probability distribution functions used in the FFA employed to estimate the parameters of seasonal and annual series. The series of seasonal and annual peak flows in period of 1951-2005 for 38 gauging stations distributed evenly throughout the major rivers in Poland was selected for the analysis.

Contrary to the expectations, the analysis of Polish rivers data did not reveal any higher homogeneity in the seasonal series than in the annual ones, neither in terms of the best-fitted model, nor a trend or standard deviation. On the other hand, one cannot deny that the trends in the Polish winter and summer series of peak flows are different which justifies the use of non-stationary approach to estimate the annual flood quantiles by seasonal approach. The non-stationary seasonal approach to estimation of annual peak flows was one of the main subjects analysed in the project I supervised (the grant of the Ministry of Science and Information Technology, completed in the late 2011). The method was corrected, comprehensively improved and expanded by the new models. The Monte Carlo simulation results and the theoretical analyses carried out on the real time series for Polish rivers showed that two-step method gives more accurate estimates of time-dependent flood quantiles than the classical method (MLM) and it is less prone to the model error. The two-stage method is now the subject of intensive research and soon the articles describing the results of this procedure in the context of its pros and cons will be published.

My contribution to the article nr. (10) was significant (40%). I actively contributed in the work at every stage of the development of the paper: from formulation and discussion of the issues to the analysis of results and drawing conclusions. I have written the software and performed all the calculations and analysed the results presented in the article; I wrote the substantial parts of the article.

(13) & (14) The interesting results obtained in previous research encouraged our team to intensify the study on seasonal approach. The new outcomes were published in the two-part article in *Hydrological Processes* (published 'online first') (Part I: Strupczewski W.G., **Kochanek** K., Bogdanowicz E., Markiewicz I., 2011 and Part. II: **Kochanek** K., Strupczewski W.G., Bogdanowicz E., 2011). The calendar-based division into summer and winter flooding was retained and the reason for such a division was discussed. In the first part, on theoretical aspects of the seasonal maxima approach (SM), the Gumbel distribution (Extreme Value Type 1, EV1) as a model for each season was selected, which constitute the base for a two-component four-parameter model of extreme values (called Two-Component Extreme Value Type 1, TCEV1) used then for estimation of annual peak flows by means of SM. This model was analysed theoretically in terms of two-modality and possible suitability for the estimation of flood quantiles in Poland. Then the results of the estimation of flood quantiles obtained by the classical approach (AM) were compared with those obtained by means of TCEV1. The results confirmed previous findings that only when certain conditions are satisfied (such as small differences between seasons and small model error) the TCEV1 can withstand the competition with the simpler models currently used in the FFA. Furthermore, it was shown that when the differences in peak flows in seasonal series are significant, the large quantiles of annual maxima can be estimated by means of classical one-component models applied to the one season only, i.e. the one in which the extreme flows are larger. This discovery is of great practical importance, since it significantly simplifies the complex analysis of the season without diminishing the quality of the estimators.

In the second part of the article, using the calendar criterion, the annual maximum flows from 38 Polish stations were divided into summer and winter series. One of the arguments supporting potentially the seasonal approach rather than annual approach was the higher homogeneity of the seasonal time series.

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However, the results of research did not confirm the hypothesis of a greater regional and local homogeneity in the seasonal series than in the annual ones, both in terms of models fitted to them and the linear moments calculated for these samples. Nevertheless, the correlation coefficients calculated for the series confirmed the independence of seasonal peak flows, which opened the door for using the SM in Polish rivers. Additionally, it was demonstrated by the empirical likelihood function for samples, both seasonal and annual, that their (i.e. empirical functions') shape does not differ from commonly used in flood frequency analysis unimodal, positively-skewed probability distributions, which paved the way for their use as seasonal models. Furthermore, the two-parameter EV1 (and thus the TCEV1) and three-parameter models were analysed by means of the MLM-based tests of fit of the distributions to 38 samples. These tests showed that EV1, and thus TCEV1 should not be used in the seasonal approach in Poland. Of the selected three-parameter distributions summer season is best represented by the Pearson type III, whereas for winter it is difficult to point out an appropriate model.
To sum up, the results for the Polish data did not confirm the expected (from the theory) reduction of the uncertainty of flood quantiles estimated by seasonal approach in comparison to the classical method of annual maxima. However, under certain conditions, the seasonal approach may be complementary to the methods used in the analysis of flooding in Poland, but it is not an alternative to these methods.
My contribution in both parts of the article was very large (in the first part of 40%, while in the second 45%). I took part at each stage of the work on the paper, from concept to formulation of conclusions. I made all the calculations using the software I created.

(11) Next key topic of great practical importance in statistical hydrology I dealt with was the accuracy of the estimation of flood quantiles (i.e. ones of the high probability of non-exceedance) in the context of parameters estimation methods. This problem has been examined from the beginning of my work in the field of statistical hydrology, however, in my opinion it deserves more attention. The findings of the recent studies on this topic were presented in the article published first in *Hydrology and Earth System Sciences Discussions* (information about this publication in Appendix 3); the improved and supplemented material was then published in *Hydrology and Earth System Sciences* (Markiewicz I., Strupczewski W.G., **Kochanek** K., 2010). The study focused on assessing the quality of four estimation methods: MLM, MOM, LMM and mean deviation (MD) in cases of proper and improper choice of the model. The MC simulations used two-parameter and three-parameter models: the log-normal (LN) and GEV. The bias (B) and mean square (MSE) error served as the criteria for goodness of estimation of flood quantiles.
The results confirmed the earlier observations: when the model is false, then the flood quantile obtained by MLM is of the highest B, while the smallest is for MOM, regardless of the sample size. This greatly reduces (or actually eliminates) the ability of using MLM in practice, because the possibility of proper recognition of the distribution is limited, and the method's high efficiency (i.e. small MSE) does not compensate for the large systematic error. Moreover, this method is characterized by a high computational complexity of algorithms (especially for three-parameter distributions), and often fails for unknown reasons, when other methods give the correct solution.
I estimate contribution to this article as important (10%). To perform the calculations the some procedures designed and created by me were used. I was working on an article at all stages.

(12) Despite the lack of clear and well-established evidence there is growing belief that the extreme hydrological phenomena such as floods should be reflected by positively-skewed unimodal heavy-tailed statistical models (functions of probability distributions). On the other hand, in Poland the light-tailed Pearson Type III distribution is recommended as the best model for the FFA in Polish rivers. In the article published in *Hydrology Research* (Strupczewski W.G., **Kochanek** K., Markiewicz I., Bogdanowicz E., Weglarczyk S., Singh V.P., 2011) we tried to find the answer to the question: 'Which model is most suitable for the analysis of flood frequency in Poland?' Firstly, the thorough classification of models commonly used in the FFA in Poland and abroad in terms of their tails thickness was carried out. Next, the possibility of transformation of a light-tailed distributions function into a heavy-tailed one was examined. In addition, we evaluated the usefulness of selected probability distributions (both for light- and heavy-tailed) for Polish rivers using linear moments as the estimation method. It is worth mentioning that there is no clear division between the heavy and light-tailed distributions and that whether a distribution qualifies for one of these groups depends on the selection criterion. On the other hand, the statistical hydrology adopted a classification scheme based on the criterion of the existence of finite moments, because it turns out that the distributions of the limited moments' existence (LEM) are also distributions

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with heavy tails.
The research showed that the use of asymptotic distributions stemming from the theory of extreme events in practical applications, i.e. when measuring series are short, does not lead to improvement of results and in order to minimize the risk of mistake, the fitting of the model to data should be based on obscure but effective empirical and/or graphical methods with the assistance of at least a few discrimination methods. The LMM is recommended as the best parameter estimation method (still rarely used in Poland, although more and more common in global hydrology) which gives smaller model errors in estimating large (flood) quantiles as a direct consequence of the small bias of linear moments. So far the heavy-tailed distributions have been believed to produce higher values of quantiles than the light-tailed models. However, comparing the values of flood quantiles for several models, it was noticed that with the same values of sample classical and linear moments the MOM magnifies the value of quantiles for heavy-tailed distributions in relation to the light-tailed models. In the case of estimators obtained by the LMM such behaviour is not observed. This observation and the conclusions derived from it should be considered when designing hydraulic equipment. The most important conclusion of the study based on classical visual analysis of charts with linear-moments relationship for 39 gauging stations on rivers throughout the country is that, contrary to theoretical assumptions, the light-tailed models generally better describe the regime of Polish rivers than heavy-tailed ones.
I estimate my contribution to this article as very large (40%). I have been involved in the development of publication at every stage: from concept to conclusions and recommendations. In addition, I created software and performed all the calculations.

References:
Quesenberry C.P., Kent J. (1982) Selecting among probability distributions used in reliability. *Technometrics* 24(1):59–65

Discussion of other scientific achievements

Other important papers concerning Flood Frequency Analysis and statistical modelling of floods:

(15) Markiewicz I., Strupczewski W.G., **Kochanek**, K., Singh V.P. (2006) Discussion on „Non-stationary pooled flood frequency analysis" by J.M. Cunderlik and D.H. Burns [J.Hydrol. 276 (2003) 210-223], *J.Hydrol.* 330, 382-386. 32 points MSHE; IF: 3.118; cit 1 time (WoS) and 2 times (PoP).

(16) Strupczewski W.G., Singh V.P., **Kochanek** K. (2007) Selected problems of at-site flood frequency analysis, 2nd International Symposium on Methodology in Hydrology; Nanjing; 30 October - 1 November 2005; *IAHS-AISH Publication* Issue 311, 2007, pp. 197-203

(17) Strupczewski W.G., Markiewicz I., **Kochanek** K., Singh V.P. (2008) Short Walk into Two-Shape Parameter Flood Frequency Distributions. *Hydrology and Hydraulics*, edited by V.P. Singh, Water Resources Publications, Highlands Ranch, Colorado, 2008. Chapter 19 pp 669 – 716.

(18) Bogdanowicz, E., Strupczewski, W.G., **Kochanek**, K. (2008) Zastosowanie modelu przepływ-czas trwania- prawdopodobieństwo nieprzewyższenia do opisu charakterystyk szczytowych części fal wezbraniowych. (*An application of the model flow-time-probability of non exceedance to description of the peak flow characteristics of the flood waves*) *Przegląd Geofizyczny (Geophysical Review)*, LIII, Vol 3-4, pp 263-287. 6 points MSHE (in Polish).

(15) The FFA modelling in conditions of non-stationary water regime was the next subject I dealt with when working on the statistical hydrology. This is a significant problem, since according to the observations the number of extreme events in the rivers has increased (and is still growing) in recent years. The direct cause that attracted my interest in the subject was the article by J.M. Cunderlik and D.H. Burns (2003), which was discussed in the *Journal of Hydrology* (Markiewicz I., Strupczewski W.G., Kochanek K., Singh V.P., 2006). In this article we concentrated on the lack of a comparison method presented by J.M. Cunderlik & D.H. Burns to the classical approach in which time-dependent moments (mean and standard deviation) are calculated by the least square method.
My participation in this study was substantial (10%), in particular I was involved in formulating the concept of discussion and worked on the text at every stage of work on the paper. This discussion inspired

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me to turn my scientific interests towards the issues of non-stationarity in hydrology.

(16) The results of research on modelling the flood frequency had been summarized in the article Strupczewski, Singh and **Kochanek** (2007) and presented at the conference in Nanjing. This paper addresses the issue of restrictions for the methods of FFA, which stem mostly from the lack of knowledge on the real probability distribution describing the hydrological extreme events, small size and poor quality of the measurements series. These issues are presented in the context of previously described studies concerning the procedures of discrimination, parsimonious models (two-parameter ones) and the robustness of models and methods for estimating the largest elements in the samples. The paper also presents preliminary analysis concerning the models with two shape parameters (TSP). In the paper, *inter alia*, three ways of creating the two-shape-parameter probability distributions out of the models currently used in the FFA were presented, namely; (1) the exponential variable transformation – *Tx*, (2) the density function transformation – *Tf* and (3) cumulative distribution function – *TF*.
My participation in the work on an article was significant (20%); I took part at every stage of the work on the paper.

(17) The interesting properties of TSP models outlined in previous paragraphs were further investigated and described in an extensive chapter of the monograph (Strupczewski W.G., Markiewicz I., **Kochanek** K., Singh V.P., 2008). In this work we deepened our study of methods for obtaining TSP out of other probability distributions, in particular, these methods were used to derive a bunch of new models that can be used in flood frequency analysis and their properties were described. In addition, the formulae for the moments and linear moments for the new TSP were derived. The characteristics of models Tx-gamma (TxGa) and Inverse Gamma (IGa) were analysed in details. We made an attempt to verify the thesis that the replacement of the location parameter for by the second shape parameter will improve the quality of fit of models in their right tails, i.e. in the part 'responsible' for the estimation of flood quantiles, the number of parameters, however, that also affects the accuracy of estimation, will not change.
The most important conclusions drown from this work is the statement that not all probability distribution functions undergo transformations in all three techniques of TSP creation. Moreover, it turned out that the TSP models are usually characterised by heavier tails than their 'parents', though, as in case of the TxGa, the weight of the tail is conditional and depends on the sign of one of the shape parameters. This property makes the TSP models excellent candidates for FFA.
My contribution to this work was significant (30%). I derived large part of the TSP distributions; I made most of the computations and took part in the preparation of the article at every stage.

(18) Floods that devastated large parts of Poland in 2010 lead us to revision of the believes on the assessment of flood risk in Polish rivers. It turned out that it is often the prolonged exposure to high water on levees that causes more damage than even a single extremely large but short 'impulse' resulting in the overflow of flood water over the levee crest. This is because, the levees are weakened by the pressure of water and in consequence damage occurs after the culmination of the flood wave. In such a case, while modelling the flood wave in addition to the maximum flow one should consider other parameters, such as volume and duration of inundation. In the paper published in the *Geophysical Review* (Bogdanowicz E., Strupczewski W.G., **Kochanek** K., 2008) the new model of flood waves: 'discharge - duration of flooding - probability of non-exceedance' (QdF) with the methodology of estimation of its parameters were proposed, as an alternative to the classical FFA models. By means of models of this kind it is possible to determine the quantile of probability distribution of maximum flows that last for the (fixed) number of days as the function of the likelihood of non-exceedance and duration of flooding. The results of theoretical research were supplemented by a practical example of application of the model to the two selected series for daily flow in the Warta River in Poznań and Szczucin on the Vistula river.
The basic conclusion of this study was the usefulness and necessity of the QdF models to the analysis of the dynamics of peak flood waves. Another important application of this model is to estimate the possibility of wave peaks that can be stored e.g. in reservoirs or polders. These models are the necessary alternative to the classical models of FFA.
Model of QdF was also the basis for the model, 'duration - discharge - probability of non-exceedance' (DqF) I am currently working on and which was already presented at the conference of the European Geophysical Union '*Leonardo*' in Bratislava in late 2011. This model allows to determine explicitly the probability distribution of the durations of flow above the assumed alarm stage, or other high states, which is also crucial for risk assessment of the levee material soaking and its damage and thus in conse-

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quence for flood protection.
My contribution to this work was significant (10%). I participated in the work on the article at each stage as well as preparation of software and presentation to Bratislava.

References:

Cunderlik, J.M., Burn, D.H., 2003. Non-stationary pooled flood frequency analysis. *J. Hydrol.* 276, 210–223.

Other publications important for my career:

(19) Nawalany M., Sinicyn G., **Kochanek** K., Czyzkowski B. (2003) A decision support system for groundwater: water management issues for opencast mining. New Paradigms In Subsurface Prediction: Characterization Of The Shallow Subsurface Implications For Urban Infrastructure And Environmental Assessment. *Lecture Notes In Earth Sciences*. European Sci Fdn; Int Union Geol Sci, Commiss Management & Applicat Geosci Informat. Spa, BELGIUM, July 07-12, 2001. 99; 97-102

(20) Strupczewski W.G., **Kochanek** K., Singh V.P. (2006) On thermal inversion observed in Liberian lagoons during dry season. In a book: *Coastal Hydrology and Processes*, edited by V.P. Singh and Y.J. Xiu, *Water Resources Publications*, Highlands Ranch, Colorado, pp.395-402.

(21) Kochanek K., Tynan S. (2010) The environmental risk assessment for decision support system for water management in the vicinity of open cast mines (DS WMVOC). *Technological and Economic Development of Economy*, Volume 16, Issue 3, 2010, pp. 414-431, DOI: 10.3846/tede.2010.26. 9 points MSHE; according to the information from the web page of this journal the Impact Factor for year 2010 is 5.605.

(19) My PhD thesis concerned the issues of groundwater modelling and protection as well as the decision-making support. The effect of work on these subjects was the article presented in the conference at Spa in 2001 and published two years later as a part of big monograph (Nawalany M., Sinicyn G., **Kochanek** K., Czyzkowski B., 2003). In this paper the possible scenarios and implications of impact on environmental and social spheres of the dewatering equipment of pits belonging to the Lignite Open-Cast Mine 'Konin' were analysed. Dewatering wells excavate large quantities of groundwater in order to enable work of workforce and machinery at the bottom of the pits. They also cause the significant depression cones and the fall of water table around the mine, which poses the threat on the surrounding hydrosphere, and raises conflict with other users of groundwater. This issue calls for a consensus between the authorities and organizations representing locals and the environment on the one side and the management of the mine on the other side of the barricade. The Decision Support System (DSS), whose concept was described in the article, can 'facilitate' obtaining a balanced solution accepted by both sides of the conflict.
My contribution to this article was significant (60%). I created the concept of the Decision Support System, create the groundwater model and carried out the necessary calculations. Extensive parts of the article were prepared by me.

(21) According to the concepts presented in the previous article I designed and created the DSS and I tested it on the possible hypothetical scenarios of groundwater management in the vicinity of the mine 'Konin'. The effects of the work were presented in the article published in *Technological and Economic Development of Economy* (**Kochanek** K., Tynan S., 2010). This paper describes the technical aspects of the DSS, its methodology for estimating uncertainty and decision support algorithm. The two hypothetical scenarios for groundwater management (both implemented by the lignite mine as well as users of drinking water) and their influence on nearby lakes were also considered in the context of the efficiency of decision support algorithms implemented in the DSS.
The studies indicated the fair solutions proposed by the DSS, which thus can be easier accepted by both sides of the conflict. Moreover, the DSS offers the possibility to simulate certain water management situations prior their implementation and to estimate the risk of violation of environmental equilibrium – so that decision makers can predict the consequences of their decisions and refrain from implementing any potentially catastrophic solutions.
My contribution to this article was very high (90%): I created DSS, made all the calculating and took part in the development of publications on every stage.

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(20) A slightly different theme is presented in the article published in the monograph *Coastal Hydrology and Processes* (Strupczewski W.G., **Kochanek** K., Singh V.P., 2006). The article describes the phenomenon of the temperature inversion in the Liberian oceanic lagoons during the dry season. The Po River, ocean waves and breeze are the reasons of the dynamic daily and seasonal changes in the system of salty and fresh water surrounded by sandy lagoon barriers. All these factors cause that the water at the lagoon bottom is warmer than on the surface of the lagoons! The heavier and warmer salty water falls to the bottom whereas the surface is occupied by the fresh cold(er) water.
A reversed inversion in tropical lagoons could be used as an energy source. One has to admit also that despite the long history of hydrological studies, the natural phenomena can still surprise the researchers. The article was based on observation of the first author. However, my participation in work on the article was significant (30%); I took part in the work at each stage of publication.

In summary to the short review of my academic achievements I would like to mention that since the defence of the doctoral thesis in 2003 I was the author or co-author of **over 30 works** (a list of 30 the most significant works for my scientific development is attached in Appendix 3), of which **more then a half was published in prestigious peer-reviewed journals**, monographs and conference proceedings. According to the **list of journals by Ministry of Science and Higher Education the total number of points of all 30 publications listed in Appendix 3 equals to 380, the cumulative five-year Impact Factor is 25.080** (without the paper number 21 - Kochanek K., Tynan S., 2010), and **total number of citations according to the Web of Science is 20** (including 6 self citations), whereas **by the Publish or Perish - 32** (no information about self citations). **The Hirsch Index (Index "h") according to the Web of Science is 3 and according to the Publish or Perish equals to 4.**

Other important achievements

During my research career I delivered many presentations at prestigious Polish and international conferences; the most important presentations are:

- 2004 – The Eco-Geowater Conference in Budapest, Hungary
- 2005 – VII National Conference on Evolutionary Algorithms and Global Optimisation in Korbielów, Poland
- 2006 – The General Assembly of European Geophysical Union (EGU) in Vienna, Austria – poster
- 2007 – The XXIV General Assembly of International Union of Geodesy and Geophysics (IUGG) in Perugia, Italy
- 2008 – XXVIII International School of Hydraulics – Hydraulic Methods for Catastrophes: Floods, Droughts, Environmental Disasters in Krąg, Poland
- 2008 – Workshop of International Commission of Statistical Hydrology (STAHY) in Capri, Italy
- 2009 – International Conference on Water, Environment, Energy and Society in New Delhi, India
- 2010 – Workshop International Commission of Statistical Hydrology (STAHY) in Taormina, Italy – poster
- 2011 – Workshop Tackling with Hydrological Uncertainty in Changing Environment organized by the University of Technology of Bari and University of Potenza, Italy

I reviewed more than a dozen of papers for hydrological (and other) journals, inter alia: *Acta Geophysica*, *Journal of Flood Engineering*, *Journal of Hydrology*, *Technological and Economic Development of Economy*, *Water*, and others.

In 2005-2006, I lectured at postgraduate studies in subjects of The Basis of Programming, Creating Web Pages and Databases at the Department of Environmental Engineering, Warsaw University of Technology.

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I had three foreign placements:

- June – August 2003: in the *International Institute for Applied Systems Analysis* (IIASA), Laxenburg, Austria, Young Scientists Summer Program, research in applied hydrology;
- June 2007 – August 2008: 'post-doc' at the *Centre for Water Resources Research, School of Architecture, Landscape and Civil Engineering, University College Dublin in* Ireland, where I worked on the project 'Water Framework Directive, Integration, Negotiation and Communication of Optimal Measures with Stakeholders' (WINCOMS) and dealt with the issues of decision making in the context of implementing the Water Framework Directive in Ireland;
- April 2010 - October 2011: short-term contract at *L'Institut de recherche en technologies et sciences pour l'environnement 'Cemagref'* in Lyon, France, where worked on the project 'Extreme Rainfall and Flood Estimation' (ExtraFlo) and developed my experience in the field of analysis of the extreme events in the context of modelling of floods on the rivers of France.

In addition to the projects abroad, I was involved in several Polish research and development projects, the most important ones were:

- 2003 – 2006: '*Integrated Management of Transboundary Water Catchment – TransCat'*, a research project funded by the European Commission within the scope of the Fifth Framework Programme and the implementation of the Key Action 'Sustainable Management and Quality of Water'. Contract no EVK1-CT-2002-00 124 carried out with partners from Poland, Czech Rep., Germany, Spain, Portugal, Bulgaria, Greece, Norway and Russia; I dealt with GIS analysis and modelling of groundwater flow. **Character of participation: a researcher – team member**
- 2005 – 2008: '*Improvement of the methods and techniques of the statistical flood modelling'*, Project funded by the Polish Research Committee. No. of the project 2 P 04D 057 29, Agreement No. 0546/P04/2005/29. Implemented at the Institute of Geophysics. **Character of participation: a main researcher – team member**
- 2009: '*The development and implementation of the computerised system to collection, storage, processing and on-line presentation of environmental data.*' Joint project with the Warsaw University of Technology within the scope the Norwegian Financial Mechanism. The project was ordered by the Voivodship Inspectorate for Environmental Protection in Krakow. **Character of participation: project manager**. In 2010 the project team awarded the Prize of the Minister of Environment for 'Outstanding achievements in Science and Research';
- 2009 – 2011: '*Application of new parametric methods for hydrological design in changing environment.*' Project funded by the Ministry of Science and Information Technology and National Science Centre. No. N N307 092 037, Agreement No. 0920/B/P01/2009/37. Implemented at the Institute of Geophysics. **Character of participation: project manager**.

The prizes awarded after the defence of PhD thesis:

- 2003: The prize for the excellent doctoral dissertation, Warsaw University of Technology;
- 2008: The prize of the Management of the Institute of Geophysics for scientific achievements;
- 2010: Minister of the Environment Award or 'Outstanding achievements in Science and Research'.

Warsaw, 10th February 2012

Krzysztof Kochanek