A philippic for use of historical and paleo data in hydrology

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Floods are the major natural hazard affecting countries of WMO RAVI region, as well as they cause the greatest loss of human lives and economic damage globally. Therefore the understanding of flood regime is a necessary prerequisite for effective flood prevention and preparedness measures of society. Monitoring of river flows and evaluation of hydrological statistics that describes flood regime belongs to one of the basic duties of National Hydrological Services (NHSs).

However, while 30y periods are often used in description on climate variables, and are suitable for estimation of mean flow and several other flow characteristics, they remain insufficient for sound estimation of flood probabilities, especially when it comes to e.g. 100y flood or bigger. There are off course sound reasons for this approach. Firstly, the flood is a combination of more causing factors: most importantly precipitation and initial saturation of the basin, but some others factors might importantly contribute, such as temperature, snow, frozen ground or ice jams in case of winter and spring floods, or reservoirs initial fulfilment and operation, levee breaches, etc. in artificially affected basins. That is the reason, why in hydrology, we aim to use the longest possible time series for deriving the flood regime statistics.

Secondly, extreme floods are examples of so called “black swan” events in hydrology. Black swan theory has been introduced by Taleb (2001). What is the black swan event? Taleb (2007) shortly describes it as follows:

“*What we call here a Black Swan (and capitalize it) is an event with the following three attributes. First, it is an outlier, as it lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. Second, it carries an extreme impact. Third, in spite of its outlier status, human nature makes us concoct explanations for its occurrence after the fact, making it explainable and predictable*.”

Extreme flood perfectly fits the definition of black swan event:

1) It is an outlier, typically it represents the biggest flow ever recorded during the instrumental period.
2) It has extreme impact, not only through caused damage and loss, but also in the form of impulse for hydrological service development and flood protection measures implementation.
3) We can very well describe and model (hindcast) the event retrospectively.

Use of historical hydrology (searching for written and other information, such as flood marks, providing information about floods that occurred before the systematic observation of water stages and flows) and paleohydrology (analysis

of flood deposits, dendrochronological studies etc.) might provide some additional information of past extreme events “black swans” that would remain unrecognized otherwise. Such knowledge will not eliminate the occurrence of black swan events in hydrology, but hopefully will help us to preclude “same” black swan occurring twice, because forgotten from the first time. Let me provide an illustrative example: In 2002, extreme flood occurred in Vltava River basin in the Czech Republic. Its peak in Prague was estimated to be 5 160 $m^3.s^{-1}$, while a 100years flood value was 3 960 $m^3.s^{-1}$ at that time. Parameters of flood were simply unbelievable at that time, and even the model forecast for inflow to major Orlík reservoir was doubted because it was more than a double of Q_{100} and therefore well outside hydrologically reasonable and trustable range at that time. However, later investigation of historical materials showed that similar or even greater event hit Prague in summer 1432. Having this information before the flood of 2002, it was less surprising for hydrologists and public.

In addition the black swan nature of the event might not only be the magnitude but also the timing, development etc. For example, disastrous flash flood devastated the spa city of Carlsbad in western Bohemia (Czech Republic) in November 1890. This was a completely unexpected event, as the flash flood season in Central Europe is otherwise limited to period from May to September.

In May 1872, another disastrous flash flood occurred in Czech Republic. This time extremely large area of lower Berounka river basin was affected by precipitation resulting to disastrous flood of small streams and consequently also of Berounka river itself and Vltava river in Prague. Historical reconstruction of available information showed that it took less than 24 hours from first raindrop to peak in Prague, much shorter time than a necessary minimum for flood barrier construction in the city. Without knowing that historical event, nobody would consider such a flood as a reasonable scenario to be considered in flood protection plan and prevention.

George Santayana wrote: “*Those who do not remember the past are condemned to repeat it*”, for hydrologists and National Hydrological Services, use of methods of historical hydrology and paleohydrology, might be the way how to learn past for our today’s and future benefits. It is never too late to look back to history. So, if you are interested to start with historical hydrological investigations, you might start with an excellent introduction to methods and selected applications of historical hydrology in Europe provided by Brázdil et al. (2006) and Benito et al. (2015) our contact historians in your country.

References:

Benito, G., Brázdil, R., Herget, J., and Machado, M.J. 2015: Quantitative historical hydrology in Europe. Hydrol. Earth Syst. Sci., 19, 3517–3539, 2015 www.hydrol-earth-syst-sci.net/19/3517/2015/ doi:10.5194/hess-19-3517-2015
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Brázdil, R., Kundzewicz, Z.W., & Benito, G. 2006: Historical hydrology for studying flood risk in Europe, Hydrological Sciences Journal, 51:5, 739-764 http://dx.doi.org/10.1623/hysj.51.5.739

Taleb, N.N. 2001: Fooled by Randomness. Random House, New York, 316 p., ISBN: 0-8129-7521-9

Taleb, N.N. 2007: The Black Swan: The Impact of the Highly Improbable. Random House, New York, 366 p., ISBN 987-1-4000-6351-2

For your further interest:

PAGES Floods Working Group: http://pastglobalchanges.org/ini/wg/floods/intro

FloodList – Flood and High Water Marks: http://floodlist.com/dealing-with-floods/flood-high-water-marks

USGS Identifying and Preserving High-Water Mark Data: https://pubs.usgs.gov/tm/03/a24/tm3a24.pdf

Garde-Hansen et al: Sustainable flood memory: Remembering as resilience. http://journals.sagepub.com/doi/abs/10.1177/1750698016667453