

THE RISK OF FLOOD EVENTS OVER TIME

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Abstract

1. Risk and uncertainty in water resources arise from inherent variability of geophysical processes and complex socio-economic situations. The paper deals with the role of climatic and hydrological variability in assessing the cumulative risk of flood events over T-year period. In a broad sense a flood risk estimation integrates frequency analysis of extreme hydrological phenomena and evaluation of flood damages. We shall pay attention mostly to the probabilistic analysis of flood risks and their relations to large-scale atmospheric processes.

2. The damaging impact of floods depend on some critical values of river discharges. The probabilistic analysis should include statistical estimation of the expected annual probability of the critical discharge Q_{cr} being exceeded, and the equivalent long-term risk of exceedance over the next T years (e.g. $T = 10, 20, 50, \dots$):

$$R_T = 1 - \prod_{t=1}^T \int_0^{Q_{cr}} f(Q_{\max}, \Omega_t) dQ_{\max}$$

where Ω_t means a set of parameters of the probability density function, depending on time. In case of stationary hydrologic process $\Omega_t = \Omega = \text{const}$. If, however, the process is non-stationary, the T-year risk of flood damage may highly depend on the kind of hydrologic process variation. Does it e.g. displays a distinctive steady downward or upward trend, or is the process almost periodic? To answer these questions on a basis of relatively short observation of hydrologic data may be difficult. Possible linkages between snow-melt induced floods and some large scale meteorological phenomena will be discussed below.

3. As an example, fig. 1 shows the linear regression of spring flood discharges of Vistula river (catchment area 194 000 sq. km) on the winter (December to March) index of North Atlantic Oscillation. Similar results were obtained for a number of rivers in Central Europe.

Regression of Vistula Qmax on NAO

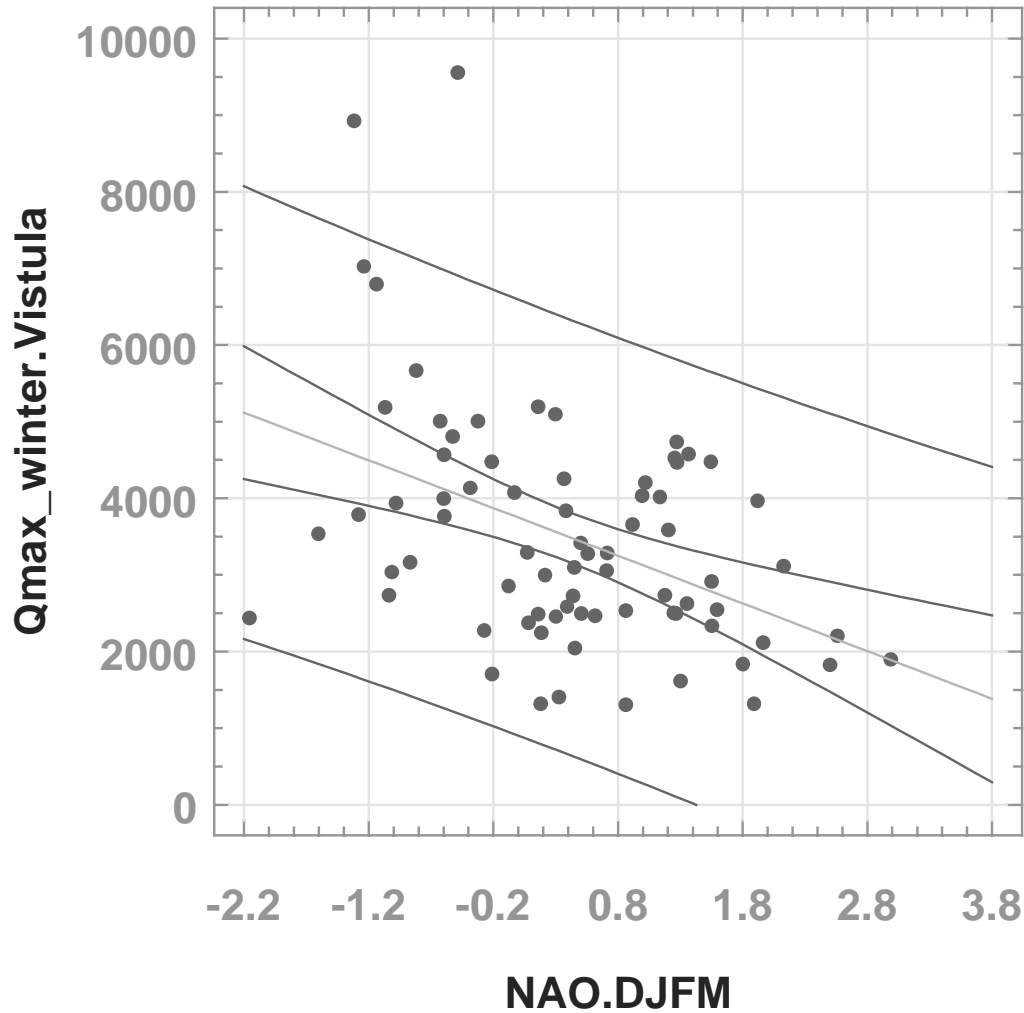


Fig. 1 Correlation of the Vistula winter floods on winter (DJFM) NAO index

4. Interesting picture of serial correlation of mean monthly river discharges (January - June) on winter NAO indices is presented on fig. 2. It is evident that for high NAO characteristics river discharges may slightly increase in winter, and decrease in April, i.e. during a typical flood period in Central Europe. Such temporal pattern of correlation is particularly visible in the eastern part of the region - river catchments of Niemen and Vistula.

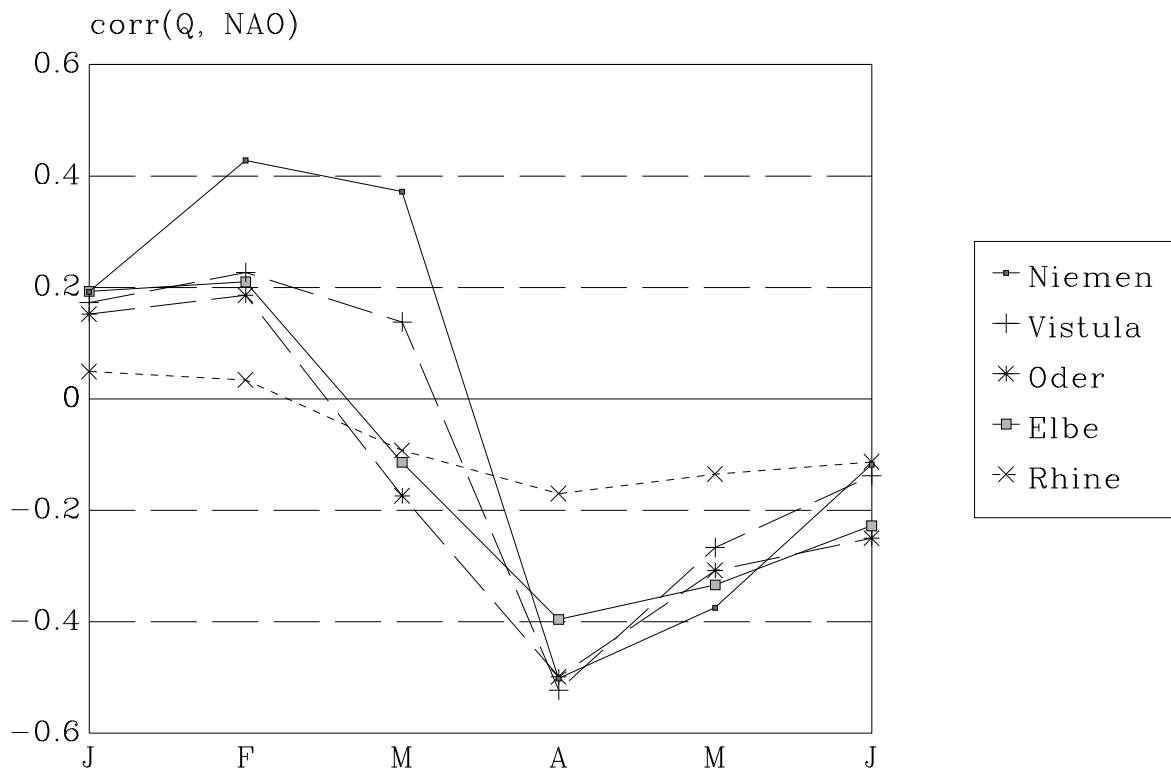


Fig. 2 Correlation of monthly discharges (January-June) on the winter (DJFM) NAO index

5. Trying to explain these regularities, an analysis of possible impact of NAO characteristics on surface air temperature T and precipitation P was implemented. Spatial distribution of correlation coefficients between NAO and T as well as NAO and P in the region under consideration is shown on fig. 3 and 4 [data of $r(\text{NAO}, P)$ are partly taken from Hurrell and van Loon, 1997]. Differences in the NAO impact on meteorological variables in various parts of the region are very significant.

6. In order to investigate the implications of NAO variations on spring flood discharges, a simple model of snow cover water equivalent (SCWE) was developed, as a function of air temperature and precipitation during winter. An application of this model to a number of Polish catchments allows to conclude that with increasing NAO the yearly maxima of SCWE values significantly decrease. This in turn may lead to decrease of spring discharges. The question of stationarity or non-stationarity of flood characteristics may therefore be linked with properties of the NAO time series.

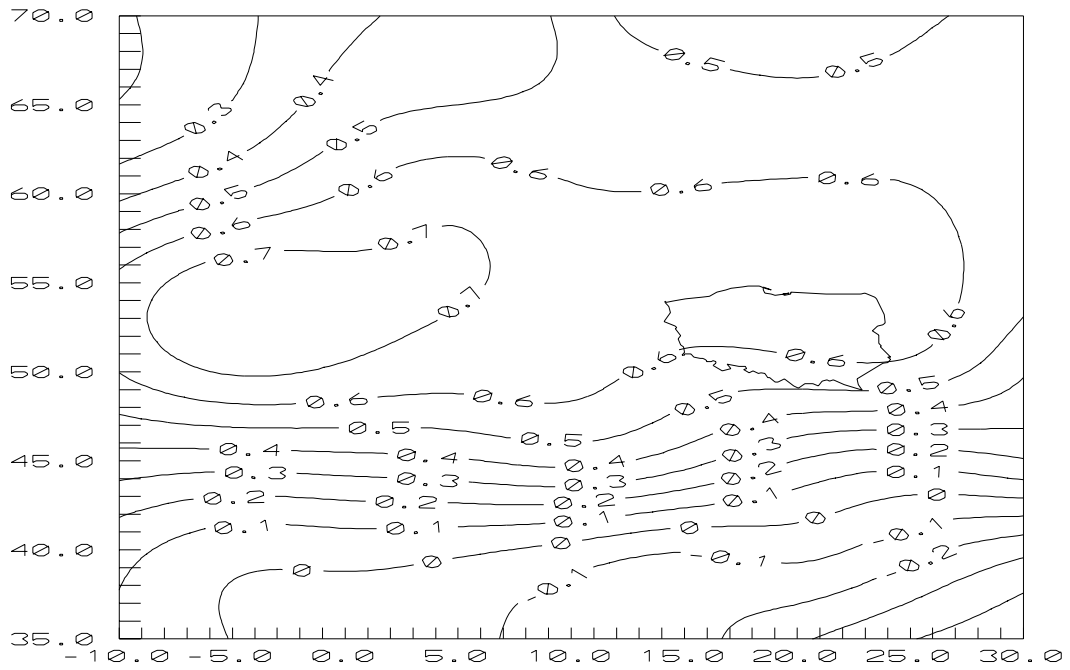


Fig. 3 Correlation of winter (DJFM) surface temperature on the winter NAO index

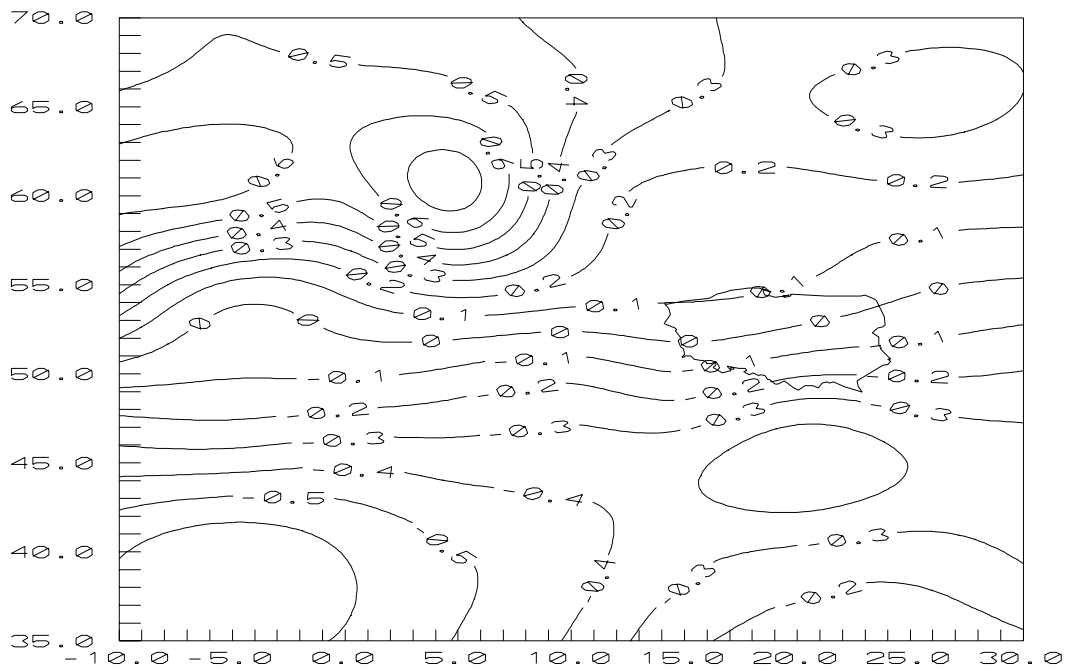


Fig. 4 Correlation of winter (DJFM) precipitation on the winter NAO index