Abstract of the doctoral dissertation "Automatic systems for modelling in hydrology"

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Three fully-automated, original systems for modelling hydrological processes are presented in the doctoral dissertation. They work in three spatial scales: global, regional and local.

The example of a solution that works in global scale is Prognocean Plus which is used for predicting sea level anomaly data with two time horizons: 14 days (based on daily data) and 12 weeks (based on weekly data). Input data are based on radar measurements carried out by altimetric satellites and have spatial resolution of 1/4° x 1/4°. Predictions of sea level change are computed using four empirical models (polynomial-harmonic, autoregression, threshold autoregression, vector autoregression) and are available as raster maps of forecasted sea level anomalies. Forecasting local sea level change based on empirical models leads to similar accuracy as predictions computed with physical methods.

The example of automated system for forecasting hydrological processes in regional or local scales is HydroProg which has been implemented for forecasting water level or discharge in the upper Nysa Kłodzka river basin with 3-hour prediction horizon and 15-minute time steps. Five empirical models (autoregression, vector autoregression, autocovariance method, two methods based on artificial neural networks) are combined with the physical one (TOPMODEL) in order to calculate a hydrologic ensemble prediction based on the multimodelling approach. The application of the multimodel ensemble does not always lead to higher accuracy than individual ensemble members. The HydroProg system has also been extended by combining it with the hydrodynamic model (FloodMap) which enabled the computation of inundation predictions. Performance of such spatial forecasts has been validated using aerial images taken with the RGB camera mounted on an unmanned aerial vehicle. It has been found that it is possible to validate inundation predictions using aerial images acquired by drones.

The fully-automated system that assists in evaluating snow-melt flood risk in local scale has been elaborated. It estimates snow depth in near real time with the use of unmanned aerial vehicles without utilizing ground control points and can be used on demand to estimate snow water equivalent. System utilizes e.g. Structure-from-Motion and Iterative Closest Point algorithms. It has been found that it is feasible to estimate snow depth, needed to calculate snow water equivalent, in an automated way using unmanned aerial vehicles without utilizing ground control points.

The presented fully-automated original modelling systems are shown to have similar skills to widely recognized solutions which often require human control. The process of automation of forecasting hydrological events is important for elaborating early warning systems against hydrological hazards which can help reduce human loss and destruction of infrastructure.