



A flexible hydrological warning system in Denmark for real-time surface water and groundwater simulations

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In Denmark, increasing focus on extreme weather events has created considerable demand for short term forecasts and early warnings in relation to groundwater and surface water flooding. The Geological Survey of Denmark and Greenland (GEUS) has setup, calibrated and applied a nationwide water resources model, the DK-Model, primarily for simulating groundwater and surface water flows and groundwater levels during the past 20 years. So far, the DK-model has only been used in offline historical and future scenario simulations. Therefore, challenges arise in operating such a model for online forecasts and early warnings, which requires access to continuously updated observed climate input data and forecast data of precipitation, temperature and global radiation for the next 48 hours or longer. GEUS has a close collaboration with the Danish Meteorological Institute in order to test and enable this data input for the DK model. Due to the comprehensive physical descriptions of the DK-Model, the simulation results can potentially be any component of the hydrological cycle within the models domain. Therefore, it is important to identify which results need to be updated and saved in the real-time mode, since it is not computationally economical to save every result considering the heavy load of data. GEUS have worked closely with the end-users and interest groups such as water planners and emergency managers from the municipalities, water supply and waste water companies, consulting companies and farmer organizations, in order to understand their possible needs for real time simulation and monitoring of the nationwide water cycle. This participatory process has been supported by a web based questionnaire survey, and a workshop that connected the model developers and the users. For qualifying the stakeholder engagement, GEUS has selected a representative catchment area (Skjern River) for testing and demonstrating a prototype of the web based hydrological warning system at the workshop, and illustrated simulated groundwater levels, streamflow and water content in the root zone. The webpages can be tailor-made to meet the requirements of the end-users and also enable flexibility to extend while the users' demand changes. The active involvement of stakeholders in the workshop provided very valuable insights and feedbacks for GEUS, relevant for the future development of the nationwide real-time modeling and water cycle monitoring system for Denmark, including possible linking to early warning and real-time forecasting systems operating at the local scale.