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HPC in Rapid Disaster Response: Numerical simulations for hazard assessment of a potential dam breach of the Kyiv cistern reservoir, Ukraine

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In this work, we demonstrate the importance of High Performance Computing (HPC) and Urgent Computing (UC) in rapid disaster response to man-made catastrophes. Using the specific case study of a potential dam breach at the Kyiv cistern reservoir in Ukraine, we show how these technologies can be used to assess the potential hazards and impacts of such an event.

The Copernicus Emergency Management Service Risk & Recovery Mapping service was activated to derive hazard assessment mapping for the protection of citizens and infrastructure in the event of a potential dam breach. The Kiev Hydroelectric Power Plant, located upstream of Kiev, has been the target of a previous rocket attack, and the threat of another successful attack cannot be ruled out. The potential consequences of a dam breach are severe and include flooding and the erosion and transport of radioactive sediment.

To determine the impact of a potential dam breach and predict its effects on citizens and infrastructure, we used the Dambreak-HySEA model, which is part of the HySEA suite. This model is specifically designed to accurately reproduce the evolution of wet/dry fronts in geophysical flows such as river flooding, flooding in rural and urban areas, and dam failures. Developed by the research group EDANYA of the University of Malaga, the model was implemented using Graphics Processor Units (GPUs) with CUDA, resulting in a significant speed-up compared to a traditional CPU implementation.

The use of HPC resources, specifically those provided by the Spanish Network for Supercomputing (RES) program Urgent computing for citizen problems, was crucial in obtaining the results within the 10-day delivery time frame with the simulation of four scenarios required by the activation: partial and complete breakage of the Kyiv Dam and the same scenarios for the Irpin Dam. These simulations were computationally complex, requiring the solution of nearly 700 million computational cells per scenario.

Overall, this study highlights the importance of utilizing HPC and UC in disaster response and risk management. By utilizing advanced numerical models and computational resources, we can more accurately predict the potential hazards and impacts of man-made catastrophes such as dam breaches, and take necessary measures to protect citizens and infrastructure.