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Towards a Scenario-based Solution for Extreme Metocean Event Simulation Applying Urgent Computing

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Abstract

Today, metocean investigations, combined with forecasts and analysis of extreme events, require new design and development approaches because of their complexity. Extreme metocean events forecasting and prevention is an urgent computing task from decision-making and for reaction point of view. In this case, urgent computing scenario is an essential part that should be included in the hazard simulation and prevention system. However, existed urgent computing technological concepts does not perfectly fit all tasks in a frame of extreme metocean events simulation. Many of these tasks should be executed during the overall lifecycle of hazard prevention system that includes not only urgent scenario but research part, as well. In this paper, we decompose all tasks in three groups by most significant computational aspects (taking into consideration different criteria of data processing and high-performance contributions) and suggest a new solution that is adaptable for both research in normal (non-urgent) and urgent computing modes, where potential tasks can be structured in the form of scenarios. Suggested solution implements CLAVIRE platform core and extends its with advanced features (regarding simulation frequency, computational performance, and data-driven computing). As an example, in the metocean subject area, a complex application for Baltic Sea simulations is presented. The case studies describe three scenarios with proposed infrastructure features that are the most interesting for highlighting relevant problems of metocean simulations within the Baltic Sea. These features are: computational optimization possibilities for real-time forecast system calibration; data replacement capabilities within retrospective ensemble extreme values analysis; and hard deadline features within uncertainty analysis of an urgent scenario for complex floods.

Keywords: Computational platform, Scenario, Extreme metocean events, Flood prevention, Urgent Computing

1. Introduction

Natural environment changes influence almost all spheres of human life (e.g., health, safety, business, technology development). As a consequence of excessive population dynamics and climate changes, humanity must live or work in regions with unfavorable natural conditions. As a precautionary measure, modern science and industry have to face these new challenges and develop methods and technologies to analyze and forecast potentially disruptive extreme events and related with them decision support process.

Such a problem leads us to the necessity of developing a scenario-based solution that applies urgent computing to make it possible to increase the accuracy of extreme event prediction and hazard reaction efficiency in strictly limited time bounds. As a solution, we employ a set of domain-specific models, which are organized in user scenarios executed within an adapted computational infrastructure. We also highlight the problems within scientific tasks of metocean forecasting that demand new approaches to computational infrastructure design.

However, critical systems for extreme metocean events prediction and prevention has to work not only in urgent mode (when disaster is very close) but also around the clock for making predictions of upcoming extreme events as early as possible. To ensure the safety and accuracy of calculations in a case of a disaster, a forecasting system should be maintained, tested, developed and adjusted in non-urgent mode. As an example of such a system could be mentioned St. Petersburg Flood Barrier system