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Inundation modeling with adaptive triangular mesh refinement - state of the art numerical methods for accurate simulation

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Inundation events, as they occur in storm surges or other exceptional tidal wave phenomena, need high spatial resolution for accuracy and realistic forecasts of coastal hazard. On the other hand, a large span of spatial scales needs to be represented in order to model the long wave behavior and the local effect accurately. The range can extend to four or five orders of magnitude, when considering typical length scales of an ocean basin in comparison to typical resolution in inundation modeling. A common technique to bridge these scales is nesting of several model resolutions. In this method, a high-resolution mesh, extending just over the inundation region of interest is nested into a coarse resolution model with simplified physical approximation, extending over the whole ocean basin. The coarsely resolved model provides boundary and initial conditions to the high-resolution model. More recently, unstructured variable resolution meshes have been introduced to seamlessly combine large scales and high-resolution local simulation.

An even more advanced step in the development is to employ adaptively refined meshes. In this approach, the mesh is locally refined during the simulation in areas, where resolution is needed. The promise of this approach is high efficiency in terms of number of unknowns and floating point operations needed, since the mesh is tailored in each time-step of the computation to the actual needs. Additionally, even if the dynamics cannot be anticipated the mesh is correctly adapted to the physical behavior of the phenomenon modeled. The challenge, however, is in computational efficiency of managing the unstructured algorithmic behavior of the simulation: unstructured data access, dynamically changing arrays, dynamic load balancing, etc.

In this presentation we introduce several examples of scale-overarching numerical approaches for inundation modeling. By handling the scale interaction more accurately by tailored numerical methods, the uncertainty in simulations can be reduced.