UHAINA : Toward a parallel operational platform for fully nonlinear/weakly dispersive coastal flooding applications: tsunamis, cyclones and storms

Christopher POETTE - 21/04/2021

Contents

Applications

The purpose is to provide in the coming years to the release of a new efficient and robust open source wave modeling platform, available for a large community of users and very suitable for practical coastal applications :

- Global and regional scales with large physical domains (hundreds or thousands km);
- Storms and hurricanes surges;

Xyntia storm's effects on La Faute sur mer (France 2010).

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Tsunami hits Sendai Bay (Japan 2011).

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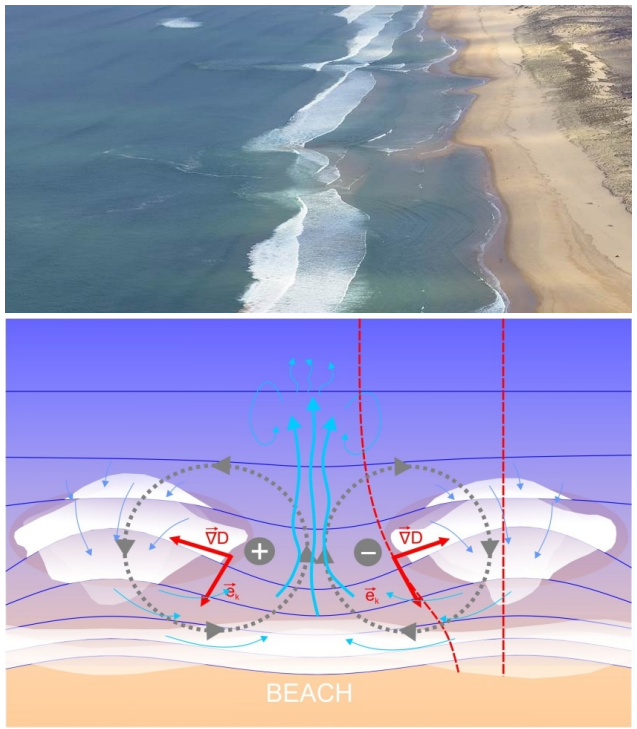
- Wave-induced circulations: rip currents;



Rip currents on the ocean coast - Castelle et al. 2013.

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- Extreme waves : tsunamis;
- Wave-induced circulations: rip currents;
- Energetic swell and storm waves (m to km):
  - Propagation in coastal environments;
  - Flooding : overtopping and overflowing;
  - Impact on coastal structures.

Wave flooding on a coastal settlement.

Consortium

- **Numerical Schemes and modeling :**

M. Ricchiuto;

C. Poette.

- **HPC, Aerosol Platform:**

V. Perrier.

- **Real applications and numerics :**

A.G. Filippini

L. Arpaia

R. Pedreros

C. Poette

- **PDE modeling :**

D. Lannes.

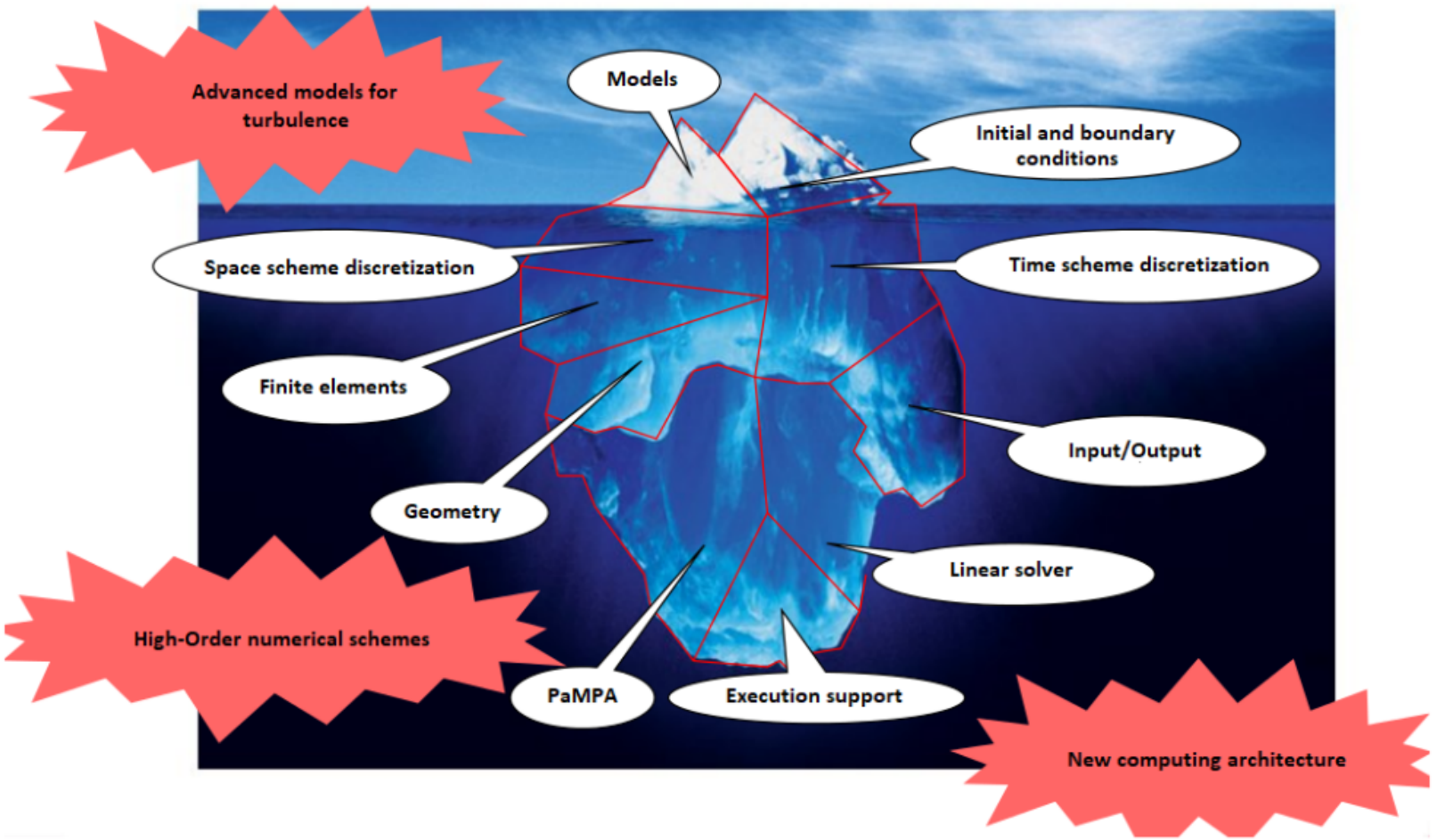
- **Physics and modeling :**

P. Bonneton.

- **High order schemes :**

F. Marche.

Using Aerosol finite elements library and its dependencies



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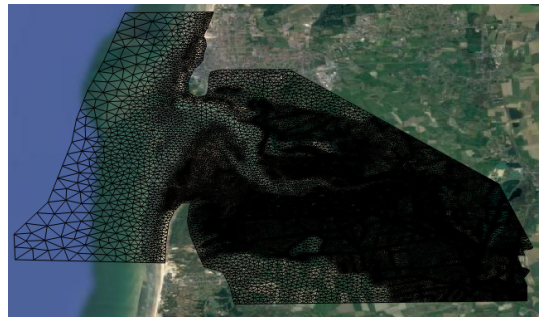
Uhaina in Aerosol

- Bathymetry; manning (friction); atmospheric pressure; wind;
- Well-balancing
  - Hydrostatic recontruction and/re pre-balanced form (Audusse et al 2004, Rogers et al 2003);
  - Well-balanced (bathymetric) correction for wet/dry interfaces(Filippini et al in prep.);
  - Mass conservative 3D/2D covariant formulation and well-balanced correction for spherical coordinates (Arpaia et al submitted)
- Bores/jumps and wet dry
  - Entropy viscosity parametrized on exact hydrostatic dissipation (guermond for EV, Filippini et al in prep.)
  - Positivity preserving limiter (shu and zhang)
  - IMEX treatment of friction terms
- Dispersive effects
  - Decoupled solution strategy SW(hyperbolic) = phi (elliptic) (Filippini et al 2016)
  - Several formulations: classical GN, diagonal, constant diagonal (Lannes and marche 2015)
- Pre/post processing : read/write standard NetCDF Ugrid files (GIS) ;

Example on a realistic test case

Authie bay, Normandie



- Number of Elements : 222328
- Mesh size : 500 m - 5 m
- Final time : 24 hours
- Computational time : 38 hours
- Number of processors : 192 procs

Conclusion:

The overall objective of the UHAINA project is to develop an open source operational platform for near shore coastal application based on the following main elements:

- Based on more efficient non-classic re-formulations of the Green-Naghdi model;
- Arbitrary high-order finite element discretization on unstructured meshes (AeroSol);
- Exploits an efficient parallel implementation (AeroSol and its dependencies) allowing HPC;
- A modular wrapping allowing for application tailored processing of all input/output data (including mesh generation, and high order visualization) for non-code-specialists;
- Uhaina is already in use for European R&D projects (Carib-Coast, Inseption) and for flooding applications (Authie bay, Corsica, Bassin d'Arcachon, French Antilles).

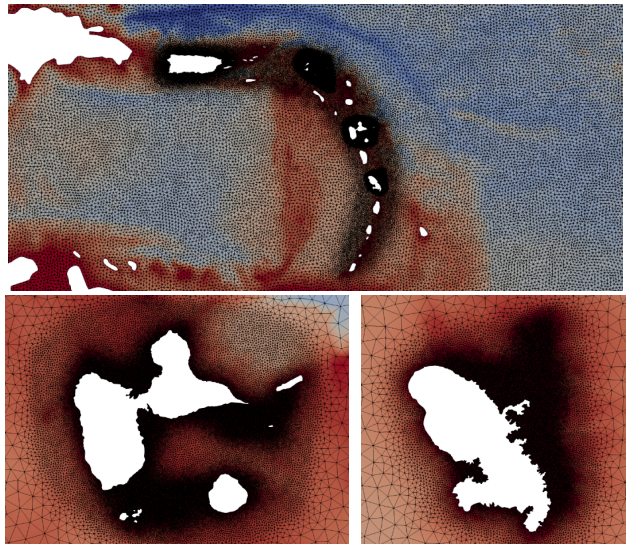
Perspectives

- More development, validation on academic tests :
  - Couple with external large scale wave model (e.g. wave watch);
  - Couple with earthquake generated Tsunami sources (e.g. Method of Satake et al 2013);
  - Impose arbitrarily complex inlet harmonic signals (based on a known spectrum, of more standard approaches as JONSWAP);
  - Post-processing: FFT, zero up analysis, runup and inundation plots on a real maps (Streemap, google terrain, etc);
  - Uhaina will be in use for 2 ANR projects (Tsunamay and Lagoon) leading to new developments : adaptive mesh, immerse boundary method, imex scheme, HPC/exascale, etc.
- Application on large scale real scenarios;
- Documentation for users;
- Diffusion to the large community of coastal researchers and engineers :
  - UHAINA-SW, beta version (mid 2021);
  - UHAINA-SW, first optimized version (end 2021);
  - UHAINA-GN, beta version (end 2021);
  - UHAINA-GN, first optimized version (2022).

Thank you for your attention

Example on a realistic test case

Tsunamis Feuillet Fault (Caribbean sea)



- Number of Elements : 350000
- Mesh size : 10 km - 0.3 km
- Final time : 5 hours
- Computational time : 9 hours
- Number of processors : 192 procs