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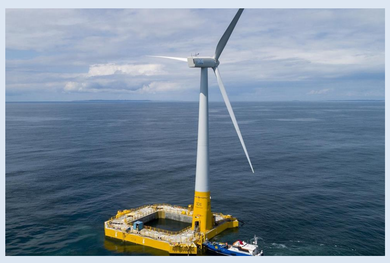
Towards accurate numerical simulation of floating wind turbines using anisotropic adaptive finite elements

L. Douteau, L. Silva, H. Digonnet, T. Coupez, D. Le Touzé and J.-C. Gilloteaux

Simulation of floating wind turbines using accurate geometry representation



FLOATGEN wind turbine operating on SEM-REV test site

- Extreme conditions
- Heavy loads on the structures
- Engineering models provide variable precision

⇒

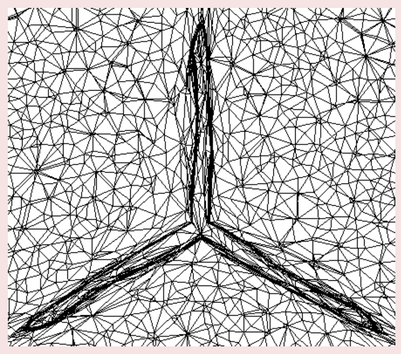
Using ICI-tech and CN SuperComputing

- Monolithic approach, unique mesh
- Exact representation of the structures (like blades)
- Massively parallel developments, runs on LIGER

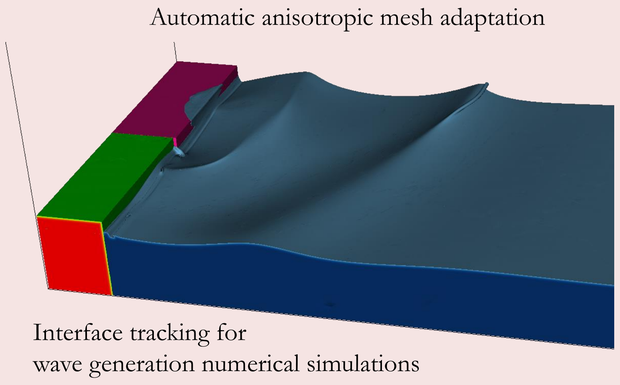
Numerical methods

Representing wind turbines

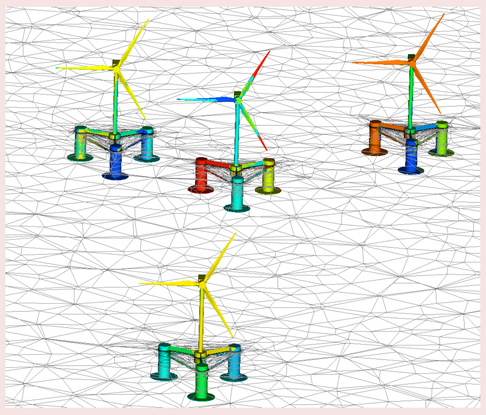
- Level-set functions for each phase
- Octree-optimized immersed volume strategy
- Anisotropic and automatic meshing from a posteriori error estimation
- Massively parallelized



Automatic anisotropic mesh adaptation



Interface tracking for wave generation numerical simulations



Parallel scalability tests on wind turbine representation

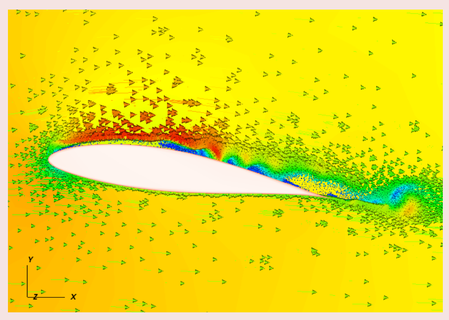
Solving the Navier-Stokes equations

- Stabilized finite elements
- Incompressible Navier-Stokes solved with a Variational MultiScale approach
- Monolithic resolution
- Linear system resolution with PETSc

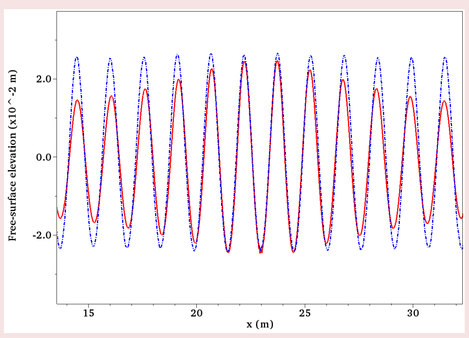
Validations

Aerodynamics

- Flows around a sphere at low Re
- Flows around NACAs at moderate Re
- Towards high Re flows on full blades
- Integration in IEA Wind – Task 29



Velocities around a NACA geometry, a classical aerodynamic benchmark



Free-surface elevation with a fixed mesh for a time step of 10^{-2}s (red) and 10^{-3}s (blue)

Hydrodynamics

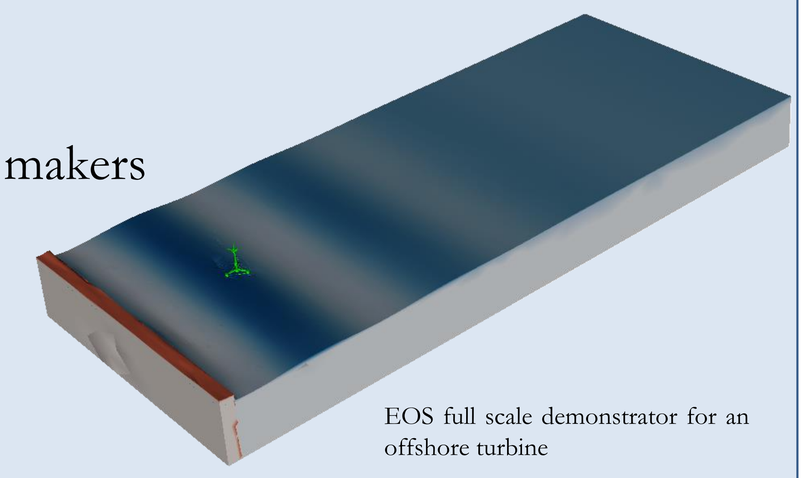
- Numerical wave basin
  - physical wave maker, with HOS-NWT [1]
  - source term approach
- Validation for target wave fields

[1] Ducrozet et al, 2012.

Floating wind turbine demonstrator

First developments

- Environmental conditions
  - Swell with physical wave makers
  - Uniform ambient wind
- Wind turbine
  - Fixed foundations
  - Rigid blades
  - Prescribed rotation
- Potential to represent several turbines



EOS full scale demonstrator for an offshore turbine

Perspectives

Validation

- Improve aerodynamic & hydrodynamic predictions

Demonstrator

- Extension to buoyancy, moorings, irregular wave fields, …

Go further

- Machine learning for scale-up purposes

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Contact

High Performance Computing Institute, 1 rue de la Noë, 44300 Nantes
direction.ici@ec-nantes.fr
https://ici.ec-nantes.fr

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