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R+D+i for a Sustainiable Development

IHFOAM applied to Coastal Engineering

Regular waves interaction with a floating structure

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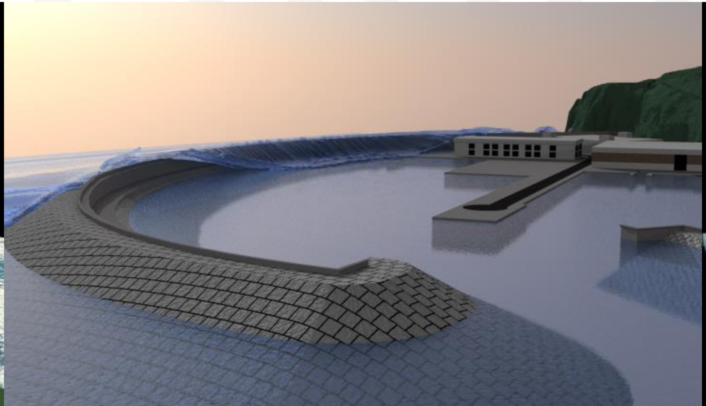
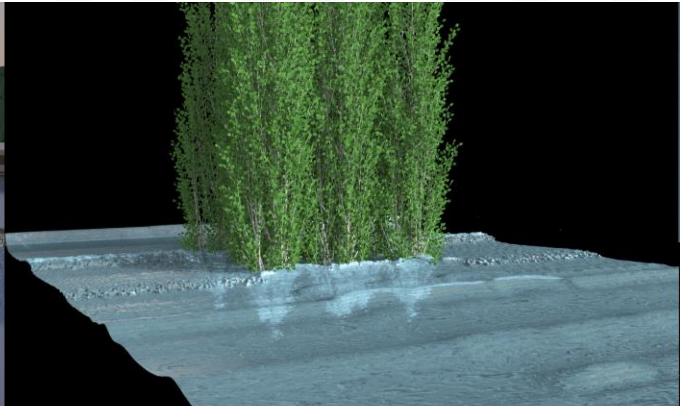



- We are going to create the case from an existing tutorial:
  - Copy the 3D case and change the folder name:

    $ cp –r ~/OpenFOAM-v1812/tutorials/multiphase/overInterDyMFoam/floatingBody ~/IHFoamCourse/

- Rename the case:
  - Rename the case:

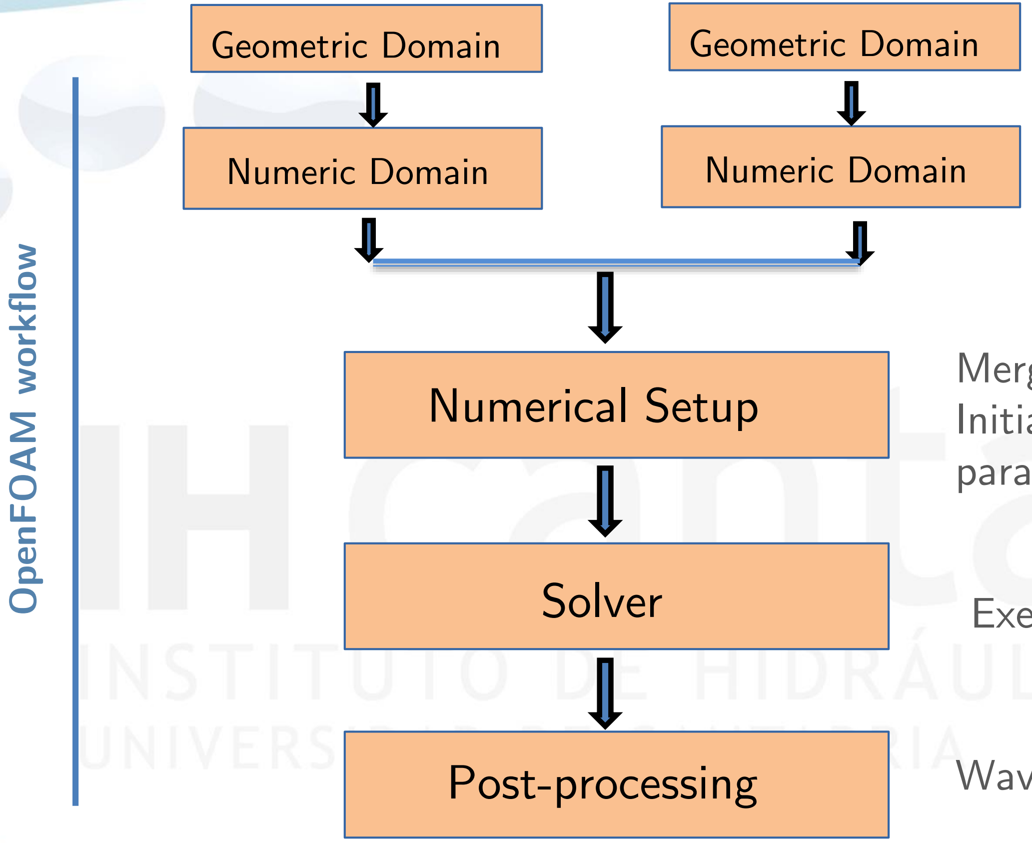
    $ mv ~/IHFoamCourse/floatingBody ~/IHFoamCourse/overSetWaves
  - Set OpenFOAM environment:

    $ source ~/OpenFOAM/OpenFOAM-v1812/etc/bashrc
  - Ensure everything you don't need is deleted

    $ cd ~/IHFoamCourse/overSetWaves

    $ ./Allclean

Regular waves interaction with a floating body

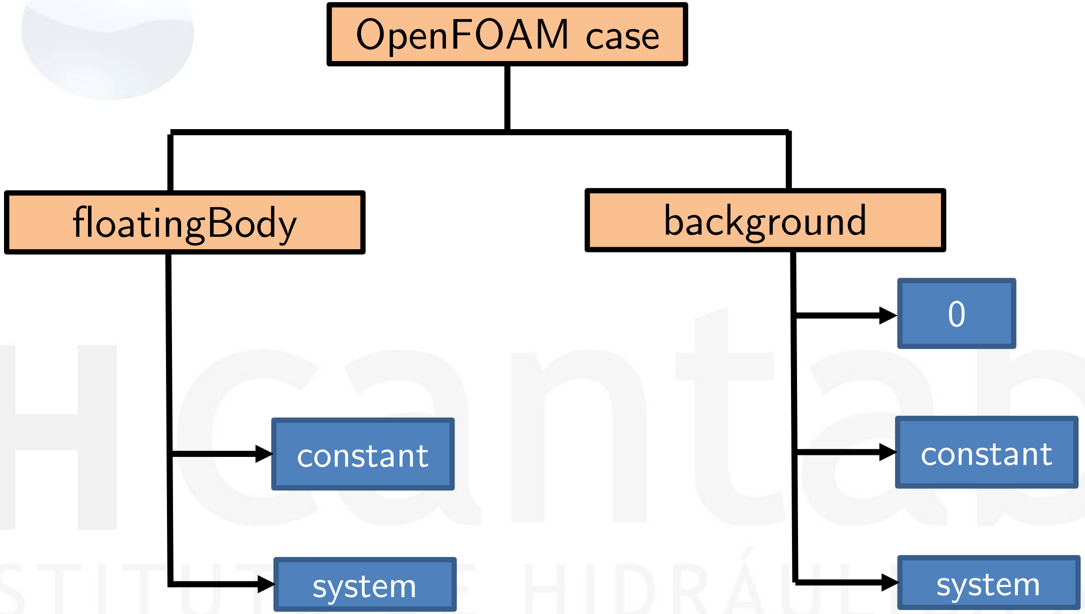


Mesh generation (object and background)

Merge meshes, Boundary conditions, Initial conditions, Numerical parameters, Pre-processing

Execute serial or parallel

Wave gauges, run-up, etc.


OpenFOAM case
floatingBody
background
constant
system
0
constant
system

Regular waves interaction with a floating body

- OpenFOAM case
  - floatingBody
    - constant
    - system
      - blockMeshDict
      - setFieldsDict
      - snappyHexMeshDict
  - background
    - 0
      - alpha.water
      - p_rgh
      - U
      - pointDisplacement
      - zoneID
      - k
      - epislon
      - nut
    - constant
      - g
      - transportProperties
      - turbulenceProperties
      - dynamicMeshDict
      - waveProperties
    - system
      - blockMeshDict
      - setFieldsDict
      - fvSchemes
      - fvSolution
      - topoSetDict
      - decomposeParDict
      - controlDict

- First, create the mesh for the floating object.
- Edit ***floatingBody/system/blockMeshDict***:

```
scale   1;

vertices
(
    (0.0 0.0 0.0)
    (0.6 0.0 0.0)
    (0.6 0.6 0.0)
    (0.0 0.6 0.0)
    (0.0 0.0 0.8)
    (0.6 0.0 0.8)
    (0.6 0.6 0.8)
    (0.0 0.6 0.8)
);

blocks
(
    hex (0 1 2 3 4 5 6 7) (20 20 30) simpleGrading (1 1 1)
);
```

```
boundary
(
    sides
    {
        type overset;
        faces
        (
            (0 3 2 1)
            (2 6 5 1)
            (1 5 4 0)
            (3 7 6 2)
            (0 4 7 3)
            (4 5 6 7)
        );
    }
    floatingObject
    {
        type wall;
        faces ();
    }
);
```

- Create the floating object base mesh:

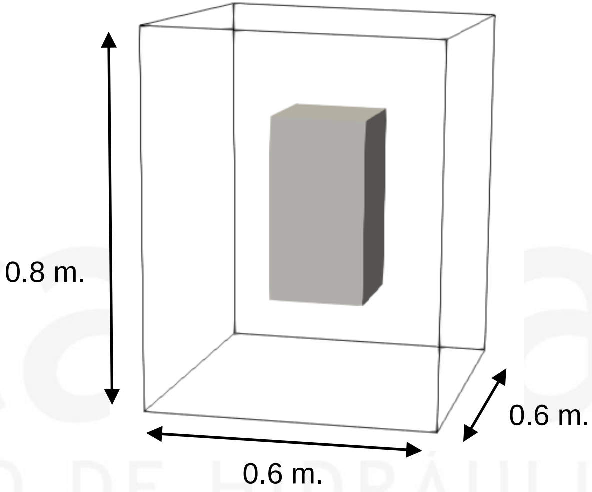
  $ blockMesh

- Check the floating object base mesh quality:

  $ checkMesh

- Define and create a mild slope (using Autocad, Rhino, etc.).
- Check the .stl file; open Paraview, load the .stl file and check that the geometry fits the base mesh:

  $ touch ih.foam && paraview



- Update the case to take into account the new geometry:

  $ mkdir constant/triSurface
  $ cp body.stl constant/triSurface/.

- Using ***snappyHexMesh***, as mesh generator to take the existing base mesh and remesh it to fit the real geometry of the experiments.

- Copy snappyHexMeshDict from a tutorial:
  $ cp –r ~/OpenFOAM-v1806/tutorials/multiphase/interFoam/RAS/mixerVesselAMI/system/
  snappyHexMeshDict ~/IHFoamCourse/overSetWaves/system/.

- This intermediate mesh, is created from the dictionary ***system/snappyHexMeshDict***:

  - ***CastellatedMesh***:
    - Mesh Refinement in prescribed regions.
    - Detection of the domain (surface and volume).
    - Removal of cells outside the domain.

```
// Which of the steps to run
castellatedMesh true;
snap            true;
addLayers       false;
```

  - ***Snap***:
    - Mesh morphing to follow the provided geometry.
    - Layer addition could also be done.

```
geometry
{
    body.stl
    {
        type triSurfaceMesh;
        name floatingObject;
    }
};
```

Definition of the a new boundary (mesh refinement and removal of cells around it).

```
nCellsBetweenLevels 1;
```

Minimun number of cells before going to the next level of resolution (Number of buffer layers between different levels.)

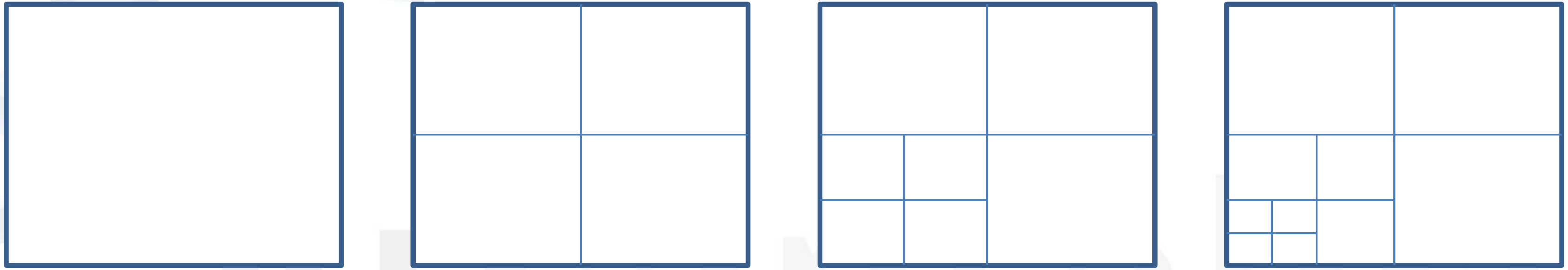
```
refinementRegions
{
}
```

List of feature edges, that describe Sharp cornes, for refinement.

```
refinementSurfaces
{
    floatingObject
    {
        level (1 2);
    }
}
```

Surface based refinements, based on two levels for every surface (the first is the minimum level, the second level is the maximum level).

- Refinement levels in OpenFOAM: increase in the refinement level reduces the cell size by half.



Level 0 Level 1 Level 2 Level 3

```
locationInMesh (0.1 0.1 0.1);
```

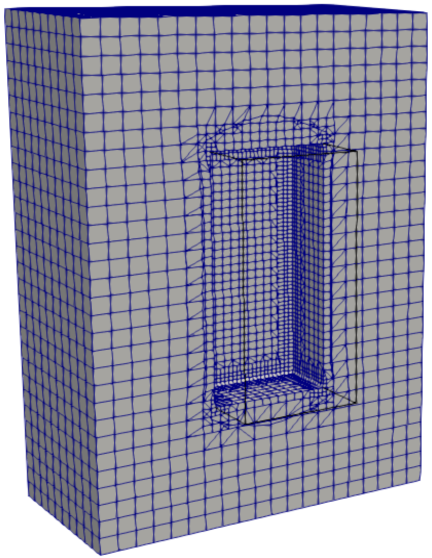
→ Cartesian points (x, y, z) to identify the volumen to retain the final mesh.

- Create the intermediate mesh:
  $ snappyHexMesh -overwrite.

- Check the floating object base mesh quality:
  $ checkMesh

- Check your final mesh with Paraview:
  $ paraview

- Load the ih.foam file. and press "*Apply*". (Remember to tick "*Skip Zero Time*", as the boundary conditions in the 0 folder have not been updated yet.)



- Next, create the mesh for the background.
- Edit ***background/system/blockMeshDict***:

```
scale   1;

vertices
(
    (-5 -1 -0.5)
    (5 -1 -0.5)
    (5 1.6 -0.5)
    (-5 1.6 -0.5)
    (-5 -1 1.5)
    (5 -1 1.5)
    (5 1.6 1.5)
    (-5 1.6 1.5)
);

blocks
(
    hex (0 1 2 3 4 5 6 7) (200 52 40) simpleGrading (1 1 1)
);
```

- Create the background base mesh:

  $ blockMesh
- Check the background base mesh quality:

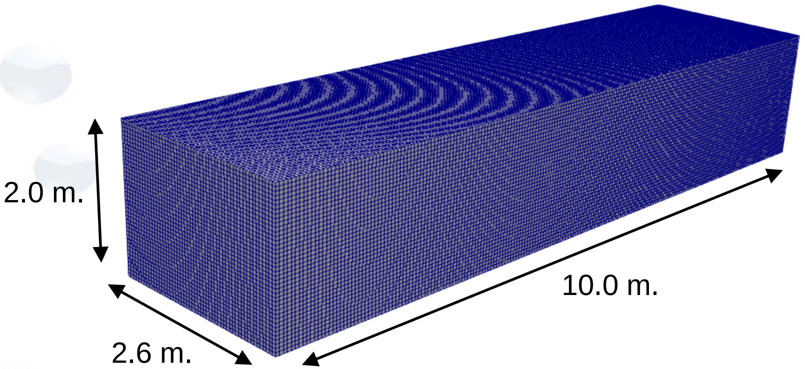
  $ checkMesh

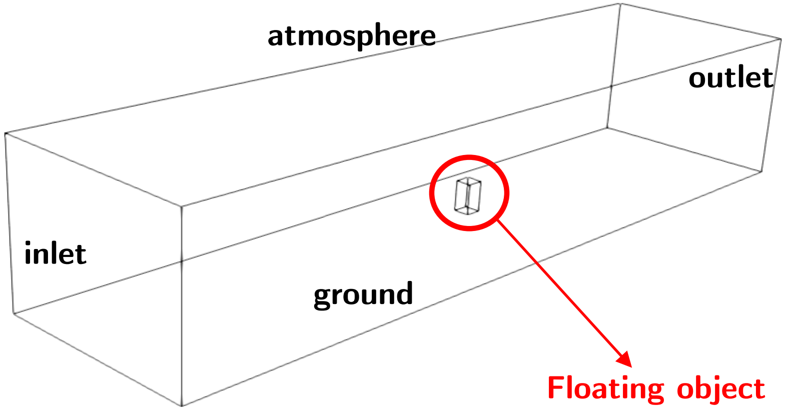
```
boundary
(
    oversetPatch
    {
        type overset;
        faces ();
    }
    inlet
    {
        type patch;
        faces
        (
            (0 4 7 3)
        );
    }
    outlet
    {
        type patch;
        faces
        (
            (1 5 6 2)
        );
    }
    ground
    {
        type wall;
        faces
        (
            (0 1 2 3)
        );
    }
    atmosphere
    {
        type patch;
        faces
        (
            (4 5 6 7)
        );
    }
    walls
    {
        type patch;
        faces
        (
            (0 1 5 4)
            (3 2 6 7)
        );
    }
);
```

- Check if the floating object and the background mesh are in concordance before merging.
  Use Paraview:

  $ touch ih.foam && paraview

- Load ***background/ih.foam*** file and press "*Apply*". (Remember to tick "*Skip Zero Time*", as the boundary conditions in the 0 folder have not been updated yet.). Load ***floatingBody/ih.foam*** too and press "*Apply*". Both meshes can be seen together.

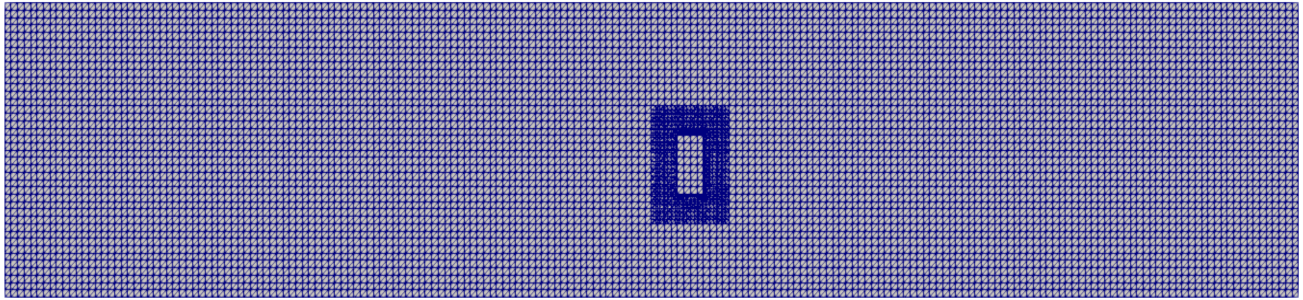




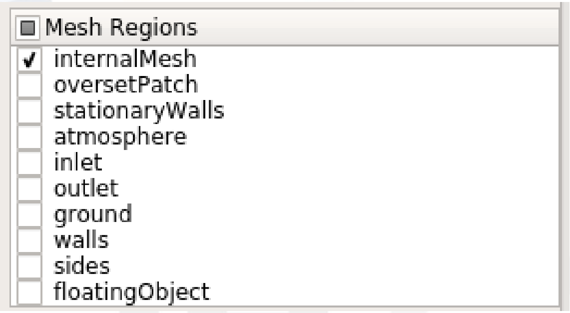
- Finally, merge both meshes to create the final and unique mesh:
  $ mergeMeshes . ../floatingBody –overwrite

- Use Paraview to visualize the final mesh:
  $ paraview

- Load the ih.foam file and press "*Apply*". (Remember to tick "*Skip Zero Time*", as the boundary conditions in the 0 folder have not been updated yet.)



- The final boundaries can be checked with Paraview (in the *Mesh Regions* dialog box) or they can be checked in the ***constant/polyMesh/boundary*** file.




```
8
(
    oversetPatch
    {
        type            overset;
        inGroups        1(overset);
        nFaces          0;
        startFace       1278608;
    }
    inlet
    {
        type            patch;
        nFaces          2080;
        startFace       1278608;
    }
    outlet
    {
        type            patch;
        nFaces          2080;
        startFace       1280688;
    }
    ground
    {
        type            wall;
        inGroups        1(wall);
        nFaces          10400;
        startFace       1282768;
    }
```

```
    atmosphere
    {
        type            patch;
        nFaces          10400;
        startFace       1293168;
    }
    walls
    {
        type            patch;
        nFaces          16000;
        startFace       1303568;
    }
    sides
    {
        type            overset;
        inGroups        1(overset);
        nFaces          3200;
        startFace       1319568;
    }
    floatingObject
    {
        type            wall;
        inGroups        1(wall);
        nFaces          3740;
        startFace       1322768;
    }
)
```

- Once the final boundaries are known, update ***0.org*** folder: VoF(***alpha.water***), velocity (***U***), pressure (***p_rgh***), mesh ID (***ZoneID***) and cell motion (***pointDisplacement***).

- The case is defined as turbulent in:

  $ more constant/turbulenceProperties

```
simulationType  RAS;

RAS
{
    RASModel        kEpsilon;

    turbulence      on;

    printCoeffs     on;
}
```

- Therefore, the turbulent kinematic energy (***k***), the turbulent dissipation (***epsilon***) and the turbulent viscosity (***nut***) variables must be defined and added to the ***0.org*** folder:

Regular waves interaction with a floating body

alpha.water:

```
dimensions      [0 0 0 0 0 0 0];
internalField   uniform 0;

boundaryField
{
    inlet
    {
        type            waveAlpha;
        value           uniform 0;
    }
    outlet
    {
        type            zeroGradient;
    }
    ground
    {
        type            zeroGradient;
    }
    walls
    {
        type            zeroGradient;
    }
    atmosphere
    {
        type            inletOutlet;
        inletValue      uniform 0;
        value           uniform 0;
    }
    floatingObject
    {
        type            zeroGradient;
    }
    overset
    {
        type            overset;
    }
    sides
    {
        type            overset;
    }
}
```

U:

```
dimensions      [0 1 -1 0 0 0 0];
internalField   uniform (0 0 0);

boundaryField
{
    inlet
    {
        type            waveVelocity;
        value           uniform (0 0 0);
    }
    outlet
    {
        type            waveVelocity;
        value           uniform (0 0 0);
    }
    walls
    {
        type            slip;
    }
    ground
    {
        type            fixedValue;
        value           uniform (0 0 0);
    }
    atmosphere
    {
        type            pressureInletOutletVelocity;
        value           uniform (0 0 0);
    }
    floatingObject
    {
        type            movingWallVelocity;
        value           uniform (0 0 0);
    }
    overset
    {
        type            overset;
    }
    sides
    {
        type            overset;
    }
}
```

p_rgh:

```
dimensions      [1 -1 -2 0 0 0 0];
internalField   uniform 0;

boundaryField
{
    inlet
    {
        type            fixedFluxPressure;
        value           uniform 0;
    }
    outlet
    {
        type            fixedFluxPressure;
        value           uniform 0;
    }
    ground
    {
        type            fixedFluxPressure;
        value           uniform 0;
    }
    walls
    {
        type            fixedFluxPressure;
        value           uniform 0;
    }
    atmosphere
    {
        type            totalPressure;
        p0              uniform 0;
    }
    floatingObject
    {
        type            fixedFluxPressure;
    }
    overset
    {
        type            overset;
    }
    sides
    {
        patchType       overset;
        type            fixedFluxPressure;
    }
}
```

zoneID:

```
dimensions      [0 0 0 0 0 0 0];
internalField   uniform 0;

boundaryField
{
    inlet
    {
        type            zeroGradient;
    }
    outlet
    {
        type            zeroGradient;
    }
    ground
    {
        type            zeroGradient;
    }
    walls
    {
        type            zeroGradient;
    }
    atmosphere
    {
        type            zeroGradient;
    }
    floatingObject
    {
        type            zeroGradient;
    }
    overset
    {
        type            overset;
    }
    sides
    {
        type            overset;
    }
}
```

pointDisplacement:

```
dimensions      [0 1 0 0 0 0 0];
internalField   uniform (0 0 0);

boundaryField
{
    inlet
    {
        type            fixedValue;
        value           uniform (0 0 0);
    }
    outlet
    {
        type            fixedValue;
        value           uniform (0 0 0);
    }
    ground
    {
        type            fixedValue;
        value           uniform (0 0 0);
    }
    walls
    {
        type            fixedValue;
        value           uniform (0 0 0);
    }
    atmosphere
    {
        type            fixedValue;
        value           uniform (0 0 0);
    }
    floatingObject
    {
        type            calculated;
        value           uniform (0 0 0);
    }
    overset
    {
        patchType       overset;
        type            zeroGradient;
    }
    sides
    {
        patchType       overset;
        type            zeroGradient;
    }
}
```

k

```
dimensions      [0 2 -2 0 0 0 0];
internalField   uniform 0.00135;

boundaryField
{
    inlet
    {
        type            zeroGradient;
    }
    outlet
    {
        type            zeroGradient;
    }
    ground
    {
        type            kqRWallFunction;
        value           uniform 0.00135;
    }
    walls
    {
        type            slip;
    }
    atmosphere
    {
        type            inletOutlet;
        inletValue      uniform 0.00135;
        value           uniform 0.00135;
    }
    floatingObject
    {
        type            kqRWallFunction;
        value           uniform 0.00135;
    }
    overset
    {
        type            overset;
    }
    sides
    {
        type            overset;
    }
}
```

epsilon

```
dimensions      [0 2 -3 0 0 0 0];
internalField   uniform 8.1505e-06;

boundaryField
{
    inlet
    {
        type            zeroGradient;
    }
    outlet
    {
        type            zeroGradient;
    }
    ground
    {
        type            epsilonWallFunction;
        Cmu             0.09;
        kappa           0.41;
        E               9.8;
        value           uniform 8.1505e-06;
    }
    walls
    {
        type            slip;
    }
    atmosphere
    {
        type            inletOutlet;
        inletValue      uniform 8.1505e-06;
        value           uniform 8.1505e-06;
    }
    floatingObject
    {
        type            epsilonWallFunction;
        Cmu             0.09;
        kappa           0.41;
        E               9.8;
        value           uniform 8.1505e-06;
    }
    overset
    {
        type            overset;
    }
    sides
    {
        type            overset;
    }
}
```

nut

```
dimensions      [0 2 -1 0 0 0 0];
internalField   uniform 0;

boundaryField
{
    inlet
    {
        type            calculated;
        value           uniform 0;
    }
    outlet
    {
        type            calculated;
        value           uniform 0;
    }
    ground
    {
        type            nutkWallFunction;
        Cmu             0.09;
        kappa           0.41;
        E               9.8;
        value           uniform 0;
    }
    walls
    {
        type            slip;
    }
    atmosphere
    {
        type            calculated;
        value           uniform 0;
    }
    floatingObject
    {
        type            nutkWallFunction;
        Cmu             0.09;
        kappa           0.41;
        E               9.8;
        value           uniform 0;
    }
    overset
    {
        type            overset;
    }
    sides
    {
        type            overset;
    }
}
```

- Using ***system/topoSet***, generate a set of cells to define the different mesh zones: $ topoSet

```
actions
(
    {
        name    c0;
        type    cellSet;
        action  new;
        source  regionToCell;
        sourceInfo
        {
            insidePoints ((-0.5 0.3 -0.1));
        }
    }

    {
        name    c1;
        type    cellSet;
        action  new;
        source  cellToCell;
        sourceInfo
        {
            set c0;
        }
    }

    {
        name    c1;
        type    cellSet;
        action  invert;
    }
);
```

regionToCell: select cells in a region; if started inside, the subCellSet keeps to it, and if outside, stays outside.

CellToCell: select cells in cellSet.

invert: select cells not in the cellSet (rest of the domain).

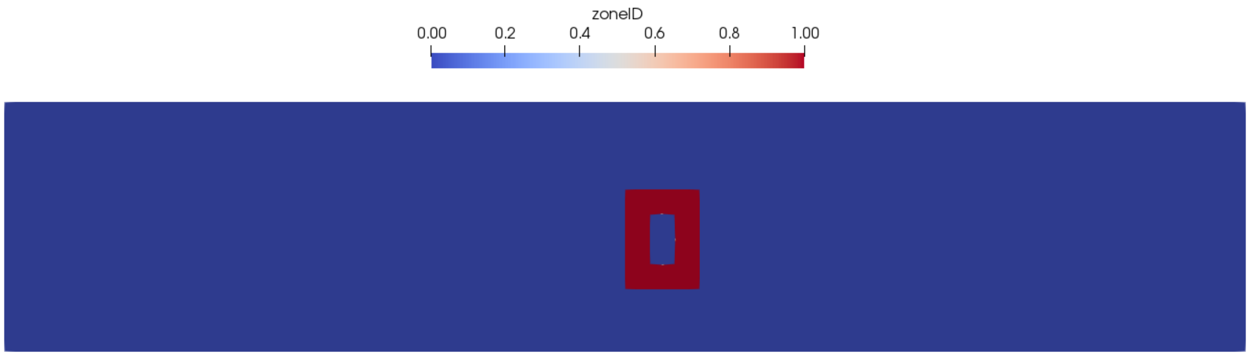
- Update the initial set-up in ***system/setFieldsDict***:
  - $ cp -r 0.org 0
  - $ setFields

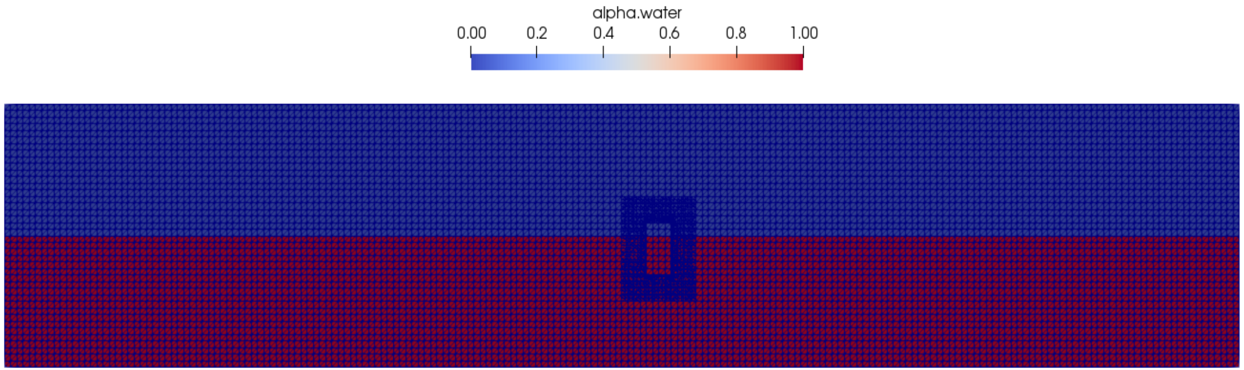
```
defaultFieldValues
(
    volScalarFieldValue alpha.water 0
    volScalarFieldValue zoneID 123
);

regions
(
    boxToCell
    {
        box ( -100 -100 -100 ) ( 100 100 0.5 );
        fieldValues ( volScalarFieldValue alpha.water 1 );
    }
    cellToCell
    {
        set c0;

        fieldValues
        (
            volScalarFieldValue zoneID 0
        );
    }
    cellToCell
    {
        set c1;

        fieldValues
        (
            volScalarFieldValue zoneID 1
        );
    }

);
```

Set initial water depth

Set zone identifiers

- Open Paraview and plot the initial set-up to ensure eveything is correct:
  $ paraview





- Copy the wavePropertiesDict from a tutorial:

  cp ~/OpenFOAM-v1806/tutorials/multiphase/interFoam/laminar/waveExampleStokesII/constant/waveProperties constant/.

- Update the wave conditions in ***constant/waveProperties***:
  - ***WaveModel***: Stokes II regular waves
  - ***nPaddle***: 2 wavepaddles (3d)
  - ***waveHeight***: H = 0.1 m.
  - ***waveAngle***: 0 (in degrees)
  - ***rampTime***: 2.0 s, smoothing time
  - ***activeAbsorption***: absorption at generation
  - ***wavePeriod***: T= 2.0 s.

  - At the outlet we also define 2 wavepaddles.

```
inlet
{
    alpha            alpha.water;

    waveModel        StokesII;

    nPaddle          2;

    waveHeight       0.1;

    waveAngle        0.0;

    rampTime         2.0;

    activeAbsorption yes;

    wavePeriod       2.0;
}
```

```
outlet
{
    alpha            alpha.water;

    waveModel        shallowWaterAbsorption;

    nPaddle          2;
}
```

- Water and air properties are defined in:
  $ more constant/transportProperties

```
phases (water air);

water
{
    transportModel  Newtonian;
    nu              [0 2 -1 0 0 0 0] 1e-06;
    rho             [1 -3 0 0 0 0 0] 1000;
}

air
{
    transportModel  Newtonian;
    nu              [0 2 -1 0 0 0 0] 1.48e-05;
    rho             [1 -3 0 0 0 0 0] 1;
}

sigma           [1 0 -2 0 0 0 0] 0.07;
```

- Gravity is defined in:
  $ more constant/g

```
dimensions      [0 1 -2 0 0 0 0];
value           ( 0 0 -9.81 );
```

- Laminar or turbulent case is defined in:
  $ more constant/turbulenceProperties

```
simulationType  RAS;

RAS
{
    RASModel        kEpsilon;

    turbulence      on;

    printCoeffs     on;
}
```

- Dynamic Motion Solver:
  - Deformation and morphing of the mesh is defined in ***constant/dynamicMeshDict***:

```
motionSolverLibs    ("libsixDoFRigidBodyMotion.so");

dynamicFvMesh       dynamicOversetFvMesh;

dynamicOversetFvMeshCoeffs
{
}

solver          sixDoFRigidBodyMotion;
```

→ Import library for the motion solver

→ Selection of class to handle mesh motion and topology changes

→ Motion solver

```
sixDoFRigidBodyMotionCoeffs
{

    patches         (floatingObject);
    innerDistance   0.2;
    outerDistance   1.0;

    centreOfMass    (0.3 0.3 0.25);

    // Cuboid dimensions
    Lx              0.2;
    Ly              0.2;
    Lz              0.4;

    // Density of the solid
    rhoSolid        700;

    // Cuboid mass
    mass            #calc "$rhoSolid*$Lx*$Ly*$Lz";

    // Cuboid moment of inertia about the centre of mass
    momentOfInertia #codeStream
    {
        codeInclude
        #{
            #include "diagTensor.H"
        #};

        code
        #{
            scalar sqrLx = sqr($Lx);
            scalar sqrLy = sqr($Ly);
            scalar sqrLz = sqr($Lz);
            os  <<
                $mass
               *diagTensor(sqrLy + sqrLz, sqrLx + sqrLz, sqrLx + sqrLy)/12.0;
        #};
    };
```

Definition of the floating object and the zone within the mesh moves as a rigid body, the zone where the mesh is morphed and the zone with no morphing.

Centre of mass of the floating object

Mass of the floating object

Density of the floating object

Mass of the floating object

Moment of inertia of the floating object

```
    report              on;
    accelerationRelaxation 0.6;

    solver
    {
        type Newmark;
    }

    constraints
    {
        fixedLine
        {
            sixDoFRigidBodyMotionConstraint line;
            direction (0 0 1);
        }
    }
}
```

Control the output of the solver (***report***) and definition of a parameter to help maintain the stability of the solver (***accelerationRelaxation*** is a direct reduction of the acceleration)

Definition of the body motion ***solver*** (***Newmark*** is a second-order time-integrator)

Definition of a constraint of the motion of the floating object (the ***line*** constraint defines a direction where the movement of the floatying object is only permited).

Numerical Schemes:

- In ***system/fvSchemes***, is the file that sets the numerical scheme for the different terms.

```
ddtSchemes
{
    default         Euler;
}

gradSchemes
{
    default         Gauss linear;
}

divSchemes
{
    div(rhoPhi,U)   Gauss limitedLinearV 1;
    div(U)          Gauss linear;
    div(phi,alpha)  Gauss vanLeer;
    div(phirb,alpha) Gauss linear;
    div(((rho*nuEff)*dev2(T(grad(U))))) Gauss linear;

    div(phi,k)      Gauss upwind;
    div(phi,epsilon) Gauss upwind;
}
```

Temporal discretization (***Euler*** is a first order implicit discretisation scheme).

Gradient derivative terms, that is surface normal gradient terms (***Gauss linear*** is second order discretisation scheme)

Divergence terms, such as advection terms and other terms that are often diffusive in nature (***Gauss limitedLinearV 1*** is second order, ***Gauss vanLeer*** is second order and ***Gauss upwind*** is a first order numerical scheme)

Numerical Schemes:

```
laplacianSchemes
{
    default         Gauss linear corrected;
}

interpolationSchemes
{
    default         linear;
}

snGradSchemes
{
    default         corrected;
}

oversetInterpolation
{
    method          inverseDistance;
}

fluxRequired
{
    default         no;
    p_rgh;
    pcorr;
    alpha.water;
}
```

Laplacian terms, such as the diffusion term in the momentum equation (values between 0 and 1 to handle a non-orthogonal mesh)

Cell to face interpolations of values (linear is second order discretisation scheme)

Component of gradient normal to a cell face (values between 0 and 1 to handle a non-orthogonal mesh)

Define overset interpolation method (***cellVolumeWeight***, ***inverseDistance***, ***leastSquares***, ***trackingInverseDistance***)

Variables needed to calculate fluxes in the pressure equation.

Algorithm control:

- In ***system/fvSolutions*** are defined the equations solvers, tolerances and algorithms.

- Controls for ***MULES***, solver of the VoF equation:
  - ***nAlphaCorr***: loops over VoF equation
  - ***nAlphaSubcycles***: number of sub-cycles within the VoF equation
  - ***cAlpha***: artificial compression velocity.
  - ***cAlpha***: artificial compression velocity.
  - ***MULESCorr***: switches on semi-implicit MULES.
  - ***nLimiterIter***: number of MULES iterations over the limiter.
  - ***solver***, ***smoother***, ***tolerance*** and ***relTol***: define the solver to solve the matrix equation (symmetric gauss seidel smoother) and tolerances.

```
solvers
{
    "alpha.water.*"
    {
        nAlphaCorr      2;
        nAlphaSubCycles 1;
        cAlpha          1;
        icAlpha         0;

        MULESCorr       yes;
        nLimiterIter    5;
        alphaApplyPrevCorr  no;

        solver          smoothSolver;
        smoother        symGaussSeidel;
        tolerance       1e-8;
        relTol          0;
    }
```

Algorithm control:

- For each variable solved in the particular equation, the type of ***solver***, ***preconditioner*** and parameters (***tolerance***, ***relTol***, ***maxIter***) that are used by the solver must be defined.

- Normally, the last iteration (variables are solved multiple times within a solution step) is solved with different parameters.

```
"cellDisplacement.*"
{
    solver          PCG;
    preconditioner  DIC;

    tolerance       1e-06;
    relTol          0;
    maxIter         100;
}

"pcorr.*"
{
    solver          PCG;
    preconditioner  DIC;
    tolerance       1e-9;
    relTol          0;
}

p_rgh
{
    solver          PBiCGStab;
    preconditioner  DILU;
    tolerance       1e-9;
    relTol          0.01;
}

p_rghFinal
{
    $p_rgh;
    relTol          0;
}

"(U|k|epsilon).*"
{
    solver          smoothSolver;
    smoother        symGaussSeidel;
    tolerance       1e-08;
    relTol          0;
}
```

Algorithm control:

- ***PIMPLE*** algorithm solves the pressure-velocity coupling in the Navier-Stokes equations.

- ***PIMPLE*** algorithm combines PISO and SIMPLE.
  - ***momentumPredictor***: switch the control for solving the momentum predictor.
  - ***nOuterCorrectors:*** number of times the total system of equations is solved on time step.
  - ***nCorrectors***: number of times the algorithm solves the pressure equation and momentum corrector in each step
  - ***nOrthogonalCorrectors***: specifies repeated solutions of the pressure equation, used to update the explicit non-ortogonal correction.
  - ***ddtCorr***: if set yes, reduces the the decoupling between pressure, velocity and velocity flux.

```
PIMPLE
{
    momentumPredictor   no;
    nOuterCorrectors    2;
    nCorrectors         2;
    nNonOrthogonalCorrectors 0;

    ddtCorr         yes;
    correctPhi      no;

    moveMeshOuterCorrectors no;
    turbOnFinalIterOnly no;
}
```

Algorithm control:

- ***RelaxationFactor***: controls of the under-relaxation, a technique used to for improving stability.
- ***Cache:*** controls data storage to make future requests faster

```
relaxationFactors
{
    fields
    {
    }
    equations
    {
            ".*" 1;
    }
}

cache
{
        grad(U);
}
```

- Define simulation parameters in ***system/controlDict***
  - Solver: ***overInterDyMFoam*** (incompressible two phase Flow, with optional mesh moving and mesh topology changes)
  - ***startTime*** (start time for the simulation), ***endTime*** (end time for the simulation), ***deltaT*** (time step of the simulation).
  - ***writeInterval*** (controls the timing of write output), ***purgeWrite*** (integer representing a limit on the number of time directories that are stored).
  - ***maxCo*** (maximun Courant Number), ***maxAlphaCo*** (maximun Courant number for the pase fields), ***maxDeltaT*** (upper limit of the time step).

```
libs            ("liboverset.so");

application     overInterDyMFoam ;

startFrom       latestTime;

startTime       0.0;

stopAt          endTime;

endTime         10;

deltaT          0.001;

writeControl    adjustableRunTime;

writeInterval   0.1;

purgeWrite      0;

writeFormat     ascii;

writePrecision  12;

writeCompression off;

timeFormat      general;

timePrecision   6;

runTimeModifiable yes;

adjustTimeStep  yes;

maxCo           2.0;
maxAlphaCo      2.0;
maxDeltaT       1;
```

- Update the runtime postprocessing sensors (*system/controlDict*)
  - to get the iso-Surface of the free surface elevation:

```
functions
{
    freeSurface
    {
        type surfaces;
        functionObjectLibs
        (
            "libsampling.so"
        );
        writeControl outputTime;
        outputInterval 1;
        surfaceFormat stl;
        interpolationScheme cellPoint;
        surfaces
        (
            topFreeSurface
            {
                type isoSurface;
                isoField alpha.water;
                isoValue 0.5;
                interpolate true;
            }
        );
        fields
        (
            alpha.water
        );
    }
```

- Decompose case:
  - ***system/decomposeParDict***: if we want to run our simulation in parallel we can decompose it using this file:
    - ***numberOfSubdomains***: set the number of parts in which we are going to split our domain.
    - ***n***: it should be equal to the number of subdomains
- Run the command:

  $ decomposePar

```
numberOfSubdomains  4;

method          hierarchical;

coeffs
{
    n           (2 2 1);
    delta       0.001;
    order       xyz;
}
```

- Run the case!

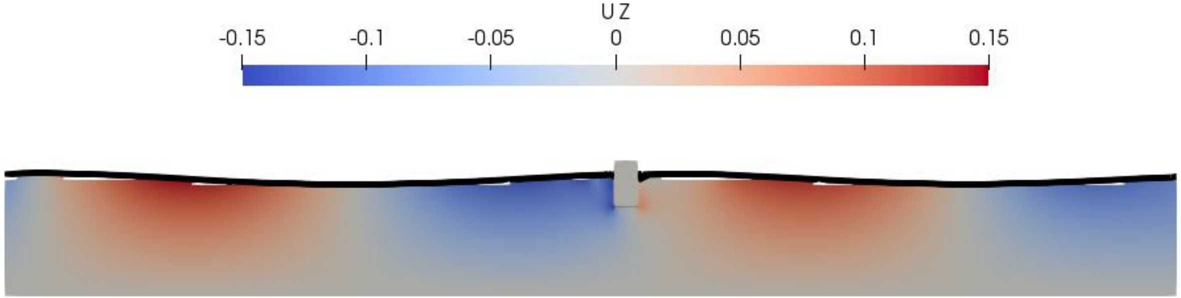
  $ mpirun –np 4 overInterDyMFoam –parallel > log.OverWaves &

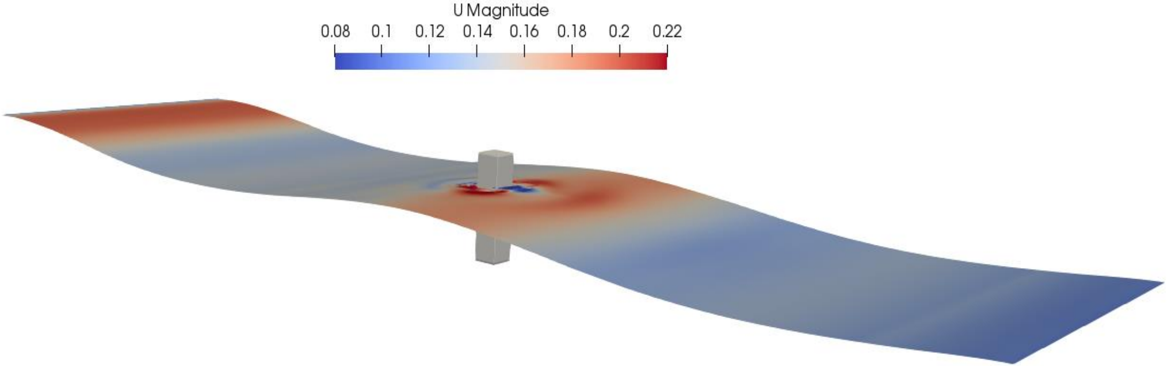
  $ tail –f log.OverWaves

  $ kill PID number

- Postprocessing with Paraview:

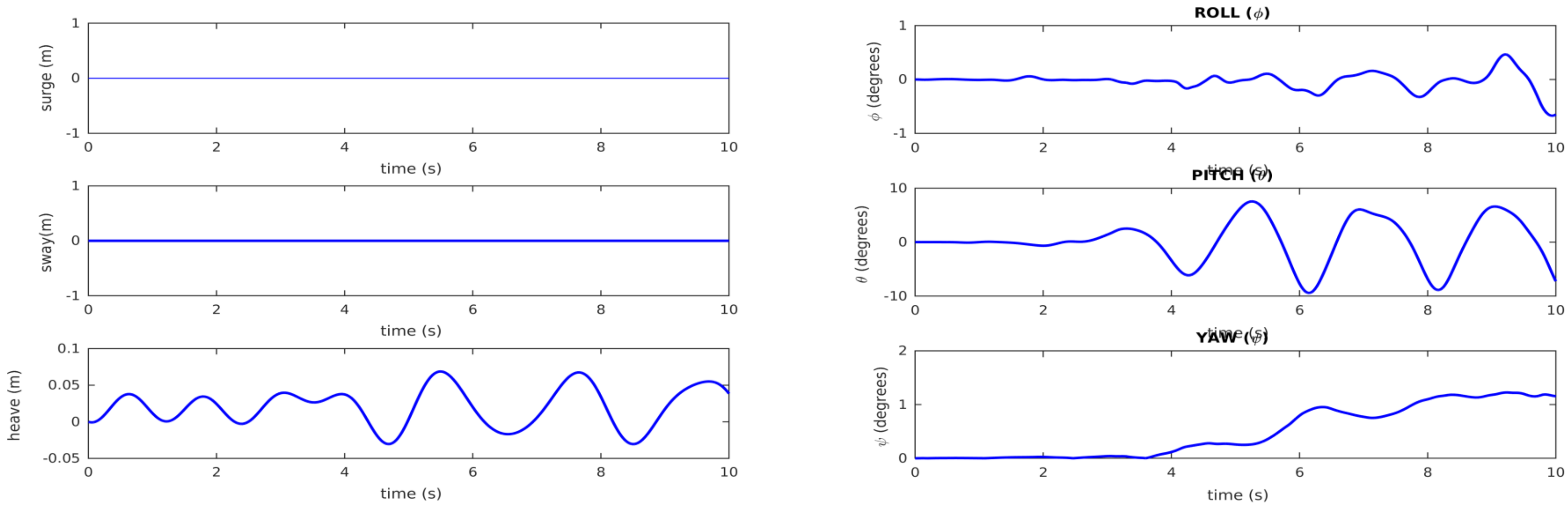
  $ paraFoam –touch





Regular waves interaction with a floating body

- Postprocessing using Matlab (six degrees of freedom, taken from log.OverWaves):



IHFOAM

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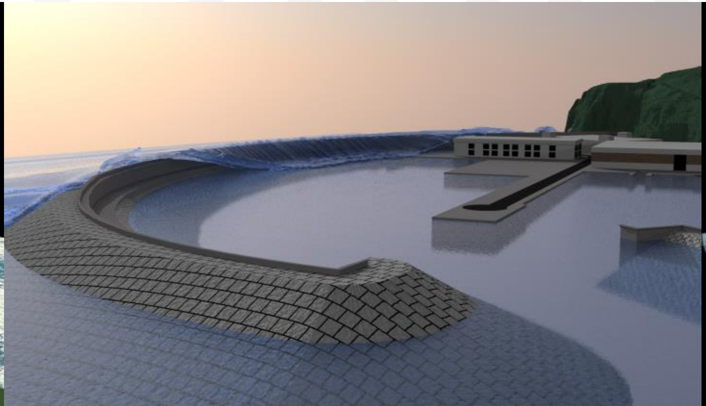

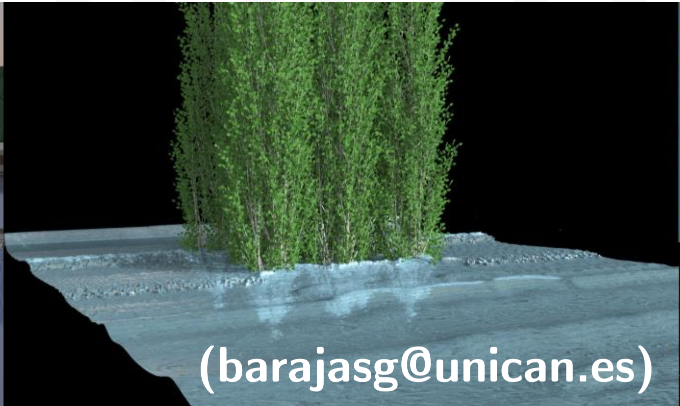

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