Code of the Month
Alya & SOD2D

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Barcelona Supercomputing Center

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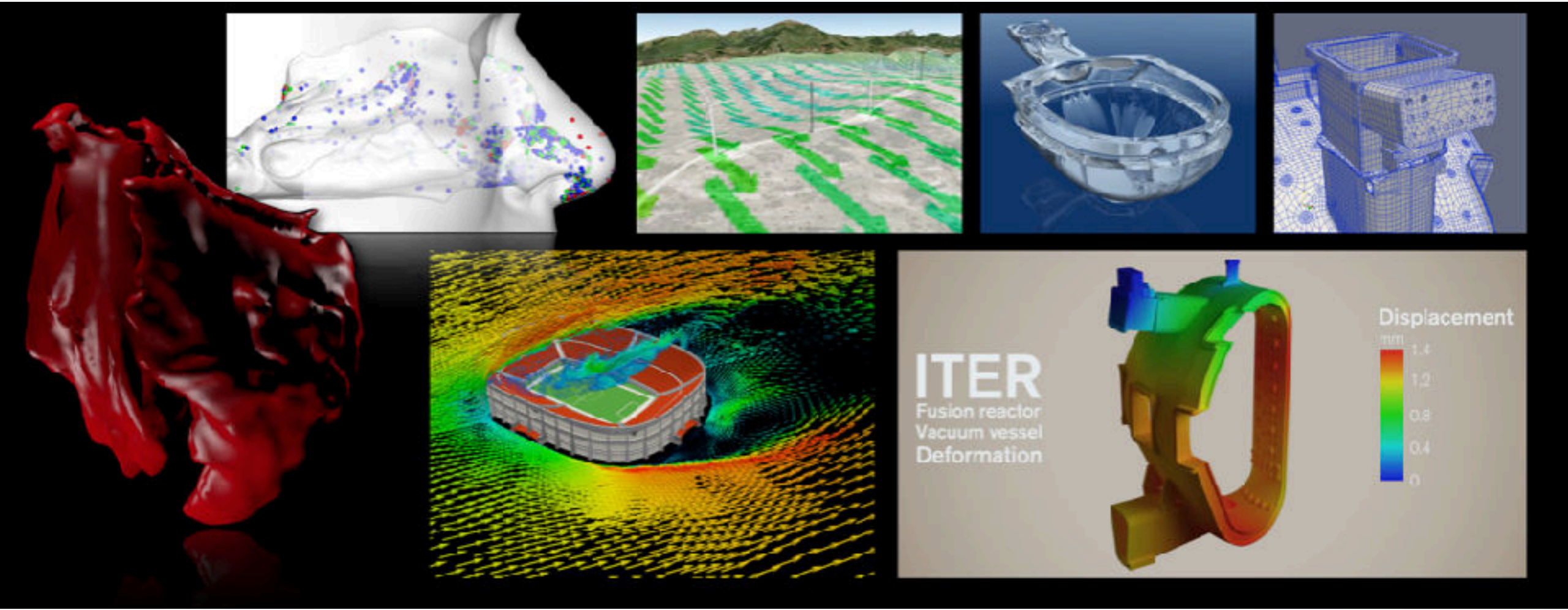
European Commission

Horizon 2020
European Union funding
for Research & Innovation

Alya

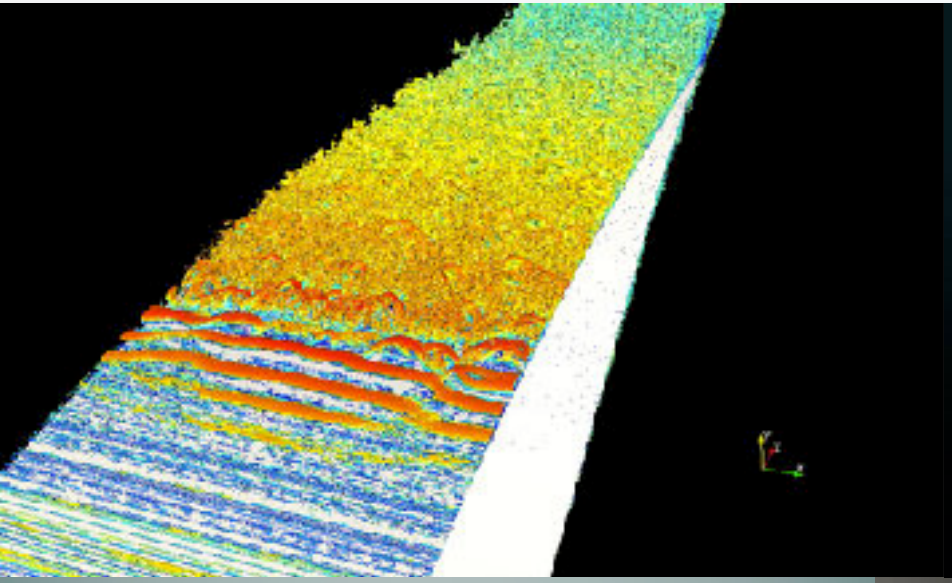
Alya: HPC finite element multiphysics code developed at BSC

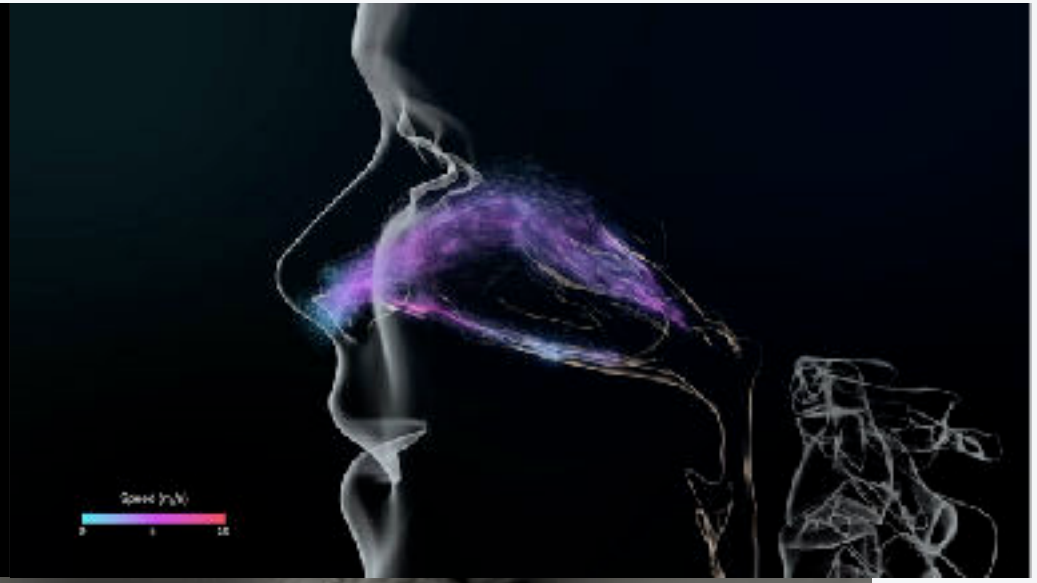
https://www.bsc.es/research-development/research-areas/engineering-simulations/alya-high-performance-computational

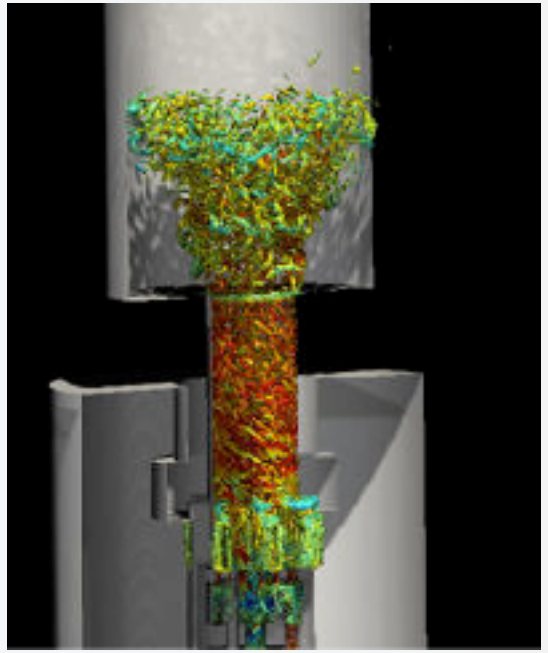


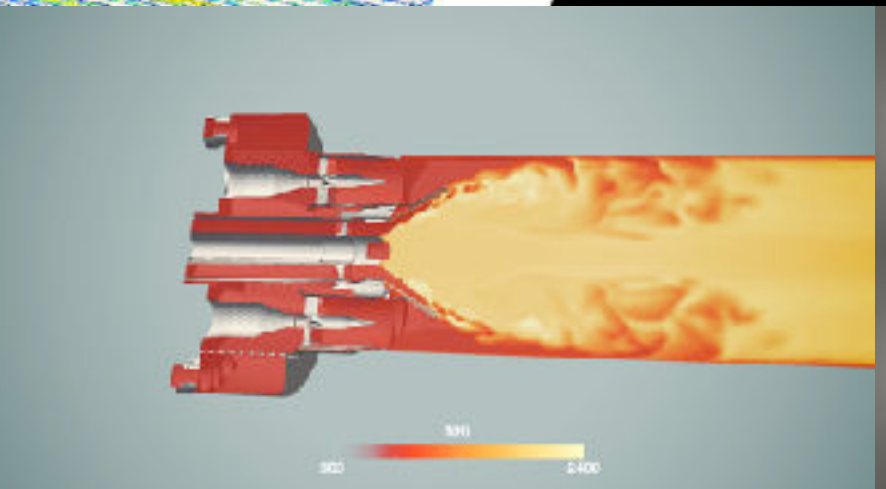
Alya

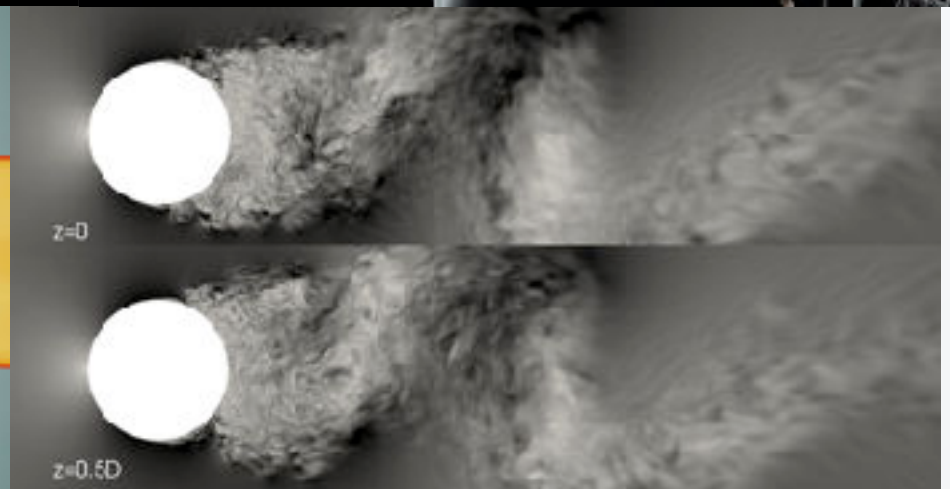
Alya is one of the two CFD codes in the Prace Benchmark Suite. Scalability has been tested on most European Supercomputers











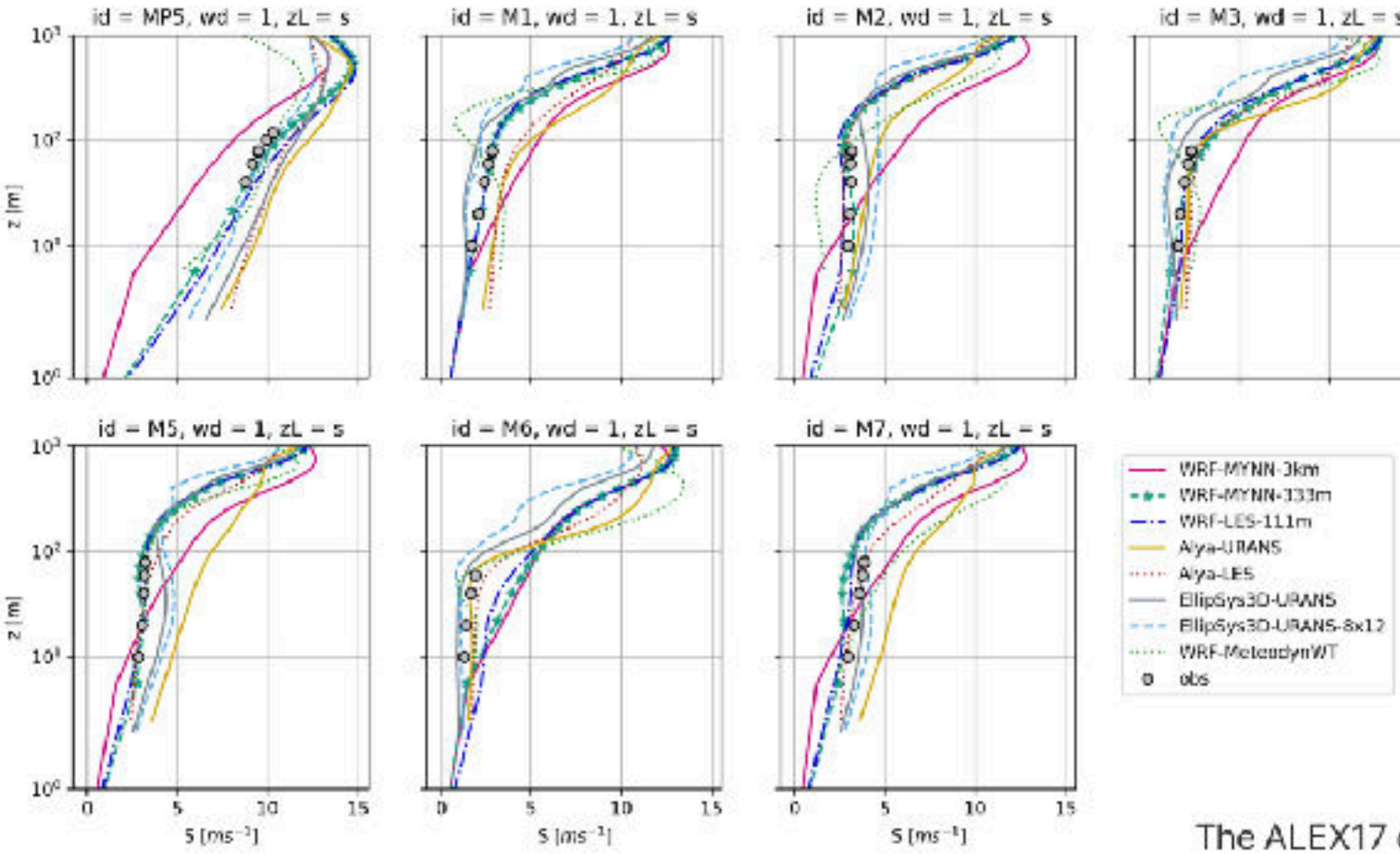
Participates/d in several CoEs:
EoCoE III
Excellerat II
CeeC
RAISE
CoeC

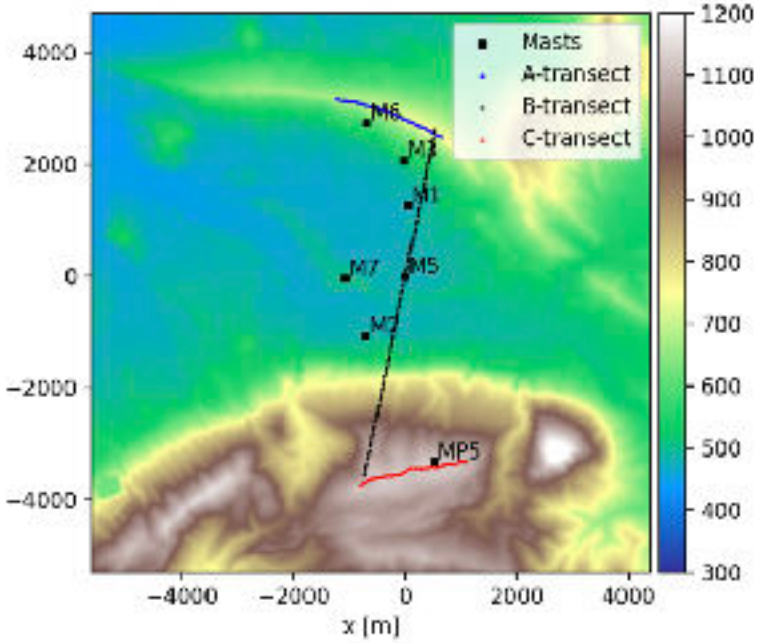
Hornamossen Benchmark

Computer resources at MareNostrum and the technical support provided by Barcelona Supercomputing Center **(RES-AECT-2018-3-0028)**

https://windbench.net/hornamossen

Wind Large Eddy Simulation - Alaiz Benchmark





Vertical profiles of wind speed at each mast for stable conditions

The ALEX17 diurnal cycles in complex terrain benchmark

J Sanz Rodrigo[1,2], P Santos[3,4], R Chávez Arroyo[5], M Avila[3], D Cavar[4], O Lehmkuhl[6], H Owen[6], R Li[7] and E Tromeur[7]

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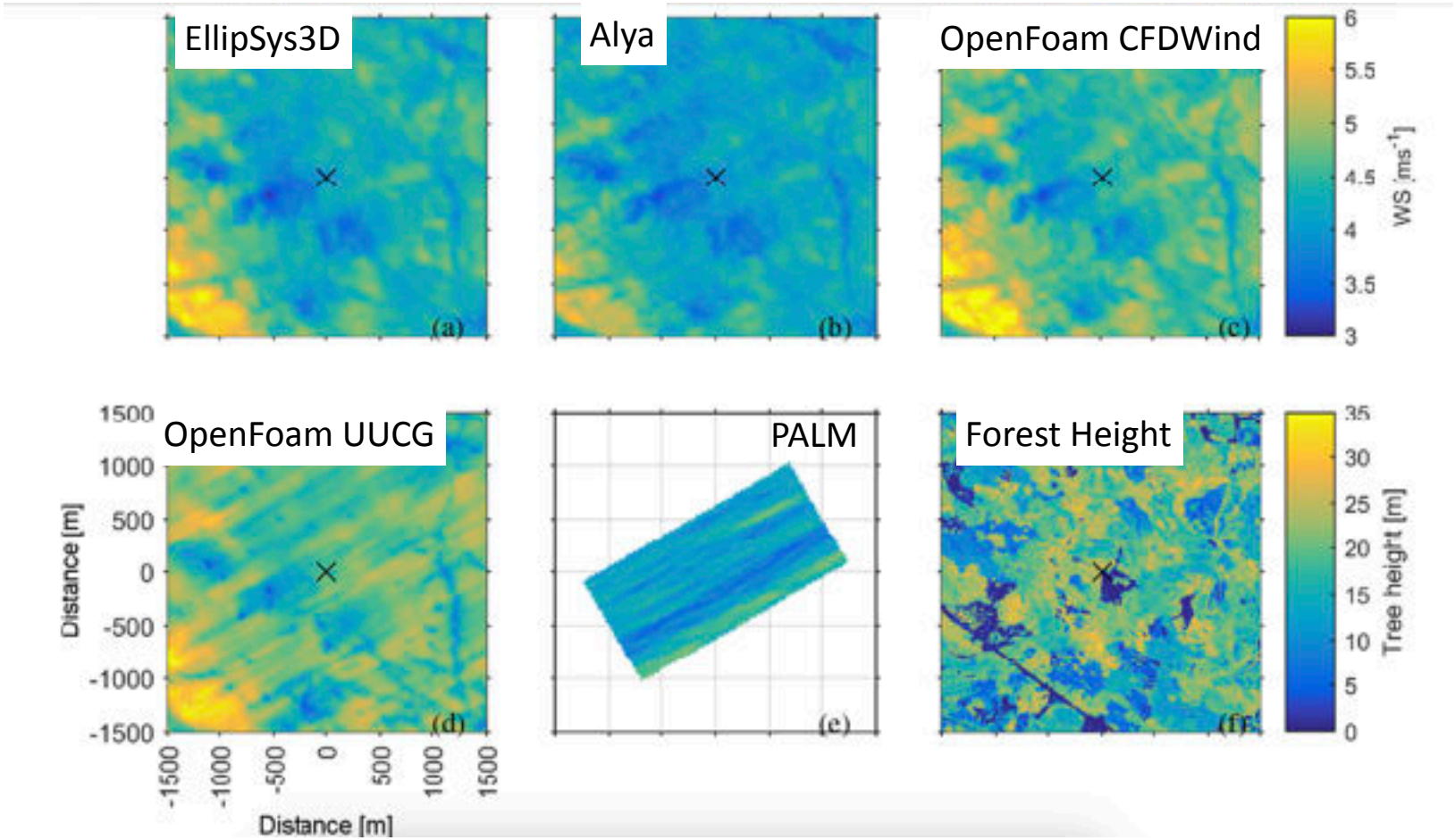
Journal of Physics: Conference Series, Volume 1934, Wake Conference 2021 15-17 June 2021, Visby, Sweden

Ryningsnäs Benchmark



Forested site with moderately complex topography in Sweden

Simulated wind speed at 40 m above the local ground height

Ivanell, S., Arnqvist, J., Avila, M., Cavar, D., Chavez-Arroyo, R. A., Olivares-Espinosa, H., Peralta, C., Adib, J., and Witha, B.: Micro-scale model comparison (benchmark) at the moderately complex forested site Ryningsnäs, Wind Energ. Sci., 3, 929–946, https://doi.org/10.5194/wes-3-929-2018, 2018

Awaken Benchmark

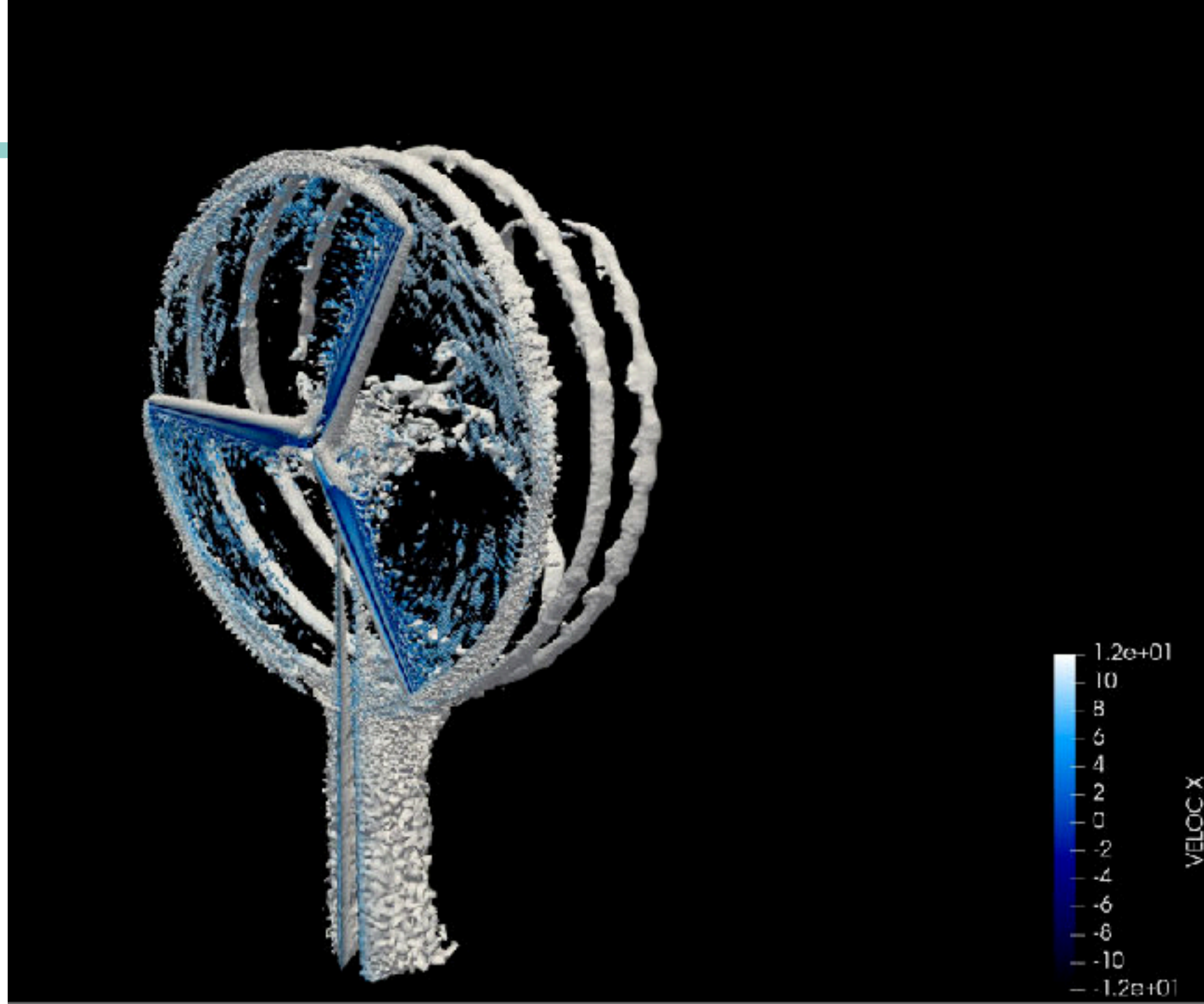
Currently the most important Wind energy benchmark is AWAKEN
Organised by NREL (US) - https://www.nrel.gov/wind/awaken.html
Unfortunately it is not free and it seems Spain will not to pay

Full rotor simulations

Full rotor model where the actual geometry of the wind turbine blades and tower is modelled exactly

Sliding mesh approach to incorporate the rotation of the blades.

Developed with Alya within EoCoE2

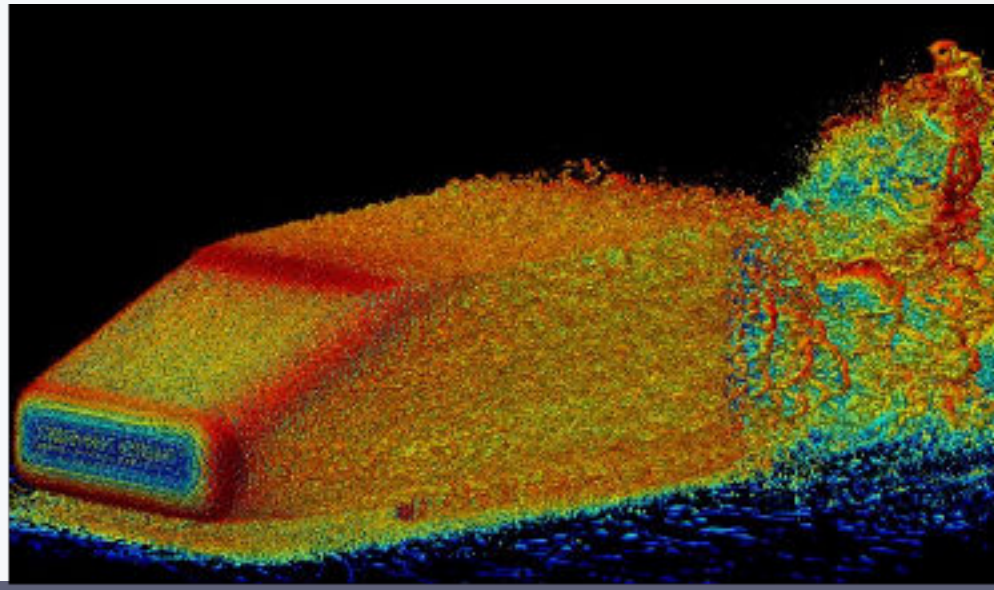


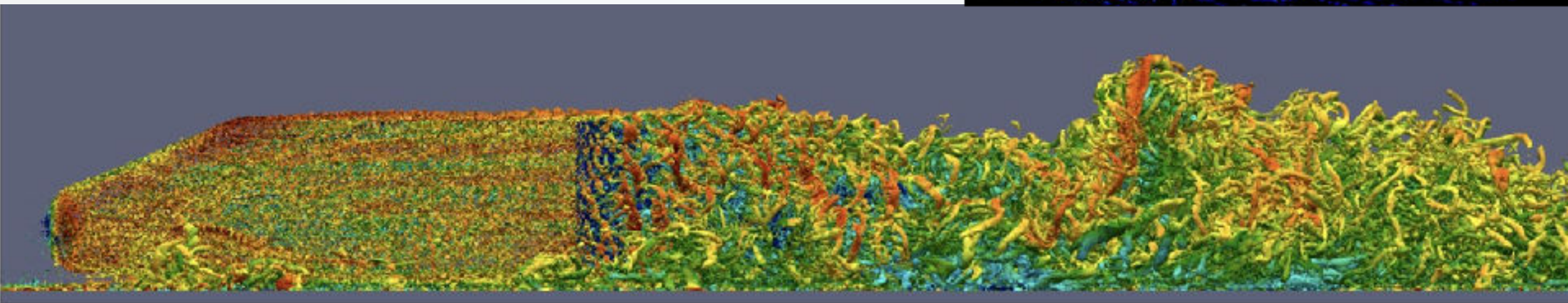
SOD2D

SOD2D: Spectral element, **high order,** flow code developed at BSC

https://gitlab.com/groups/bsc_sod2d Open source

Also Participates in EoCoE III, Excellerat II & CeeC.
Started a couple of years ago with the PhD thesis of Lucas Gasparino
Now it is the main code of the LSCFD group @ BSC.
Can be used as a library within Alya for Multiphysics problems.





SOD2D

It is now the main code of the LSCFD group @ BSC.
Focus only on CFD (Compressible and incompresible) ,will shortly include thermal coupling.
Works fully on the GPU. (Fortran + OpenACC)
Excellent scalability in several European Supercomputers.
Will shortly be tested on the full MN5 ACC. (Currently up to 2048 H100)

Compares satisfactorily against the highly mature code Nek5000

Assessment of turbulence closure strategies for large-eddy simulations within a spectral element framework
V Kumar, A Tomboulides, M Min, P Fischer, O Lehmkuhl
Bulletin of the American Physical Society

Collaboration with industry

Iberdrola

The Iberdrola group is a global energy leader
BSC has been collaborating with Iberdrola on wind resource assessment for more than **10 years.**

New physics (and numerics) has been added to **Alya** to address the needs of **wind farm modelling**.

- Coriolis forces
- Canopy terms
- Actuator disc models
- Thermal coupling for stable and convective regimes
- Modifications to RANS models
- Boundary Conditions, etc..

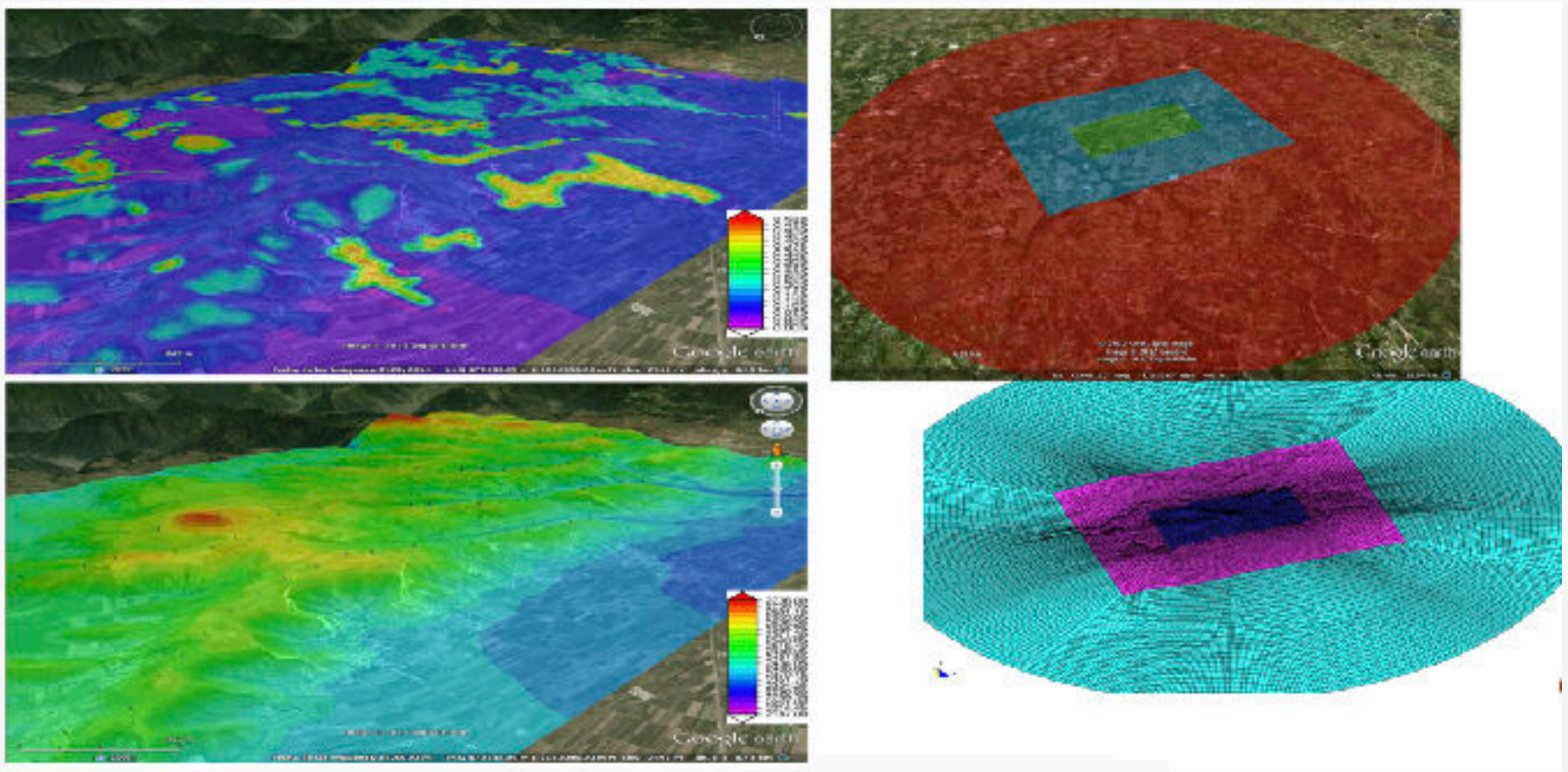
Moreover, BSC has developed specific pre and post- processing tools.

Iberdrola can run Alya as a more powerful alternative to comercial codes.

Iberdrola - Preprocesing - mesh generation

WindMesh generates a structured background mesh of hexahedral elements from terrain information (topography, roughness, canopy)

- Flat buffer zone to accommodate the flow and boundary layer near the surface
- Visualisation of terrain data using Google Earth overlays



Iberdrola - Preprocesing - mesh generation

1. Topography

- Surface defined from an STL, a point set, a contour map, etc.
- Noise filtering: signal processing smoothing

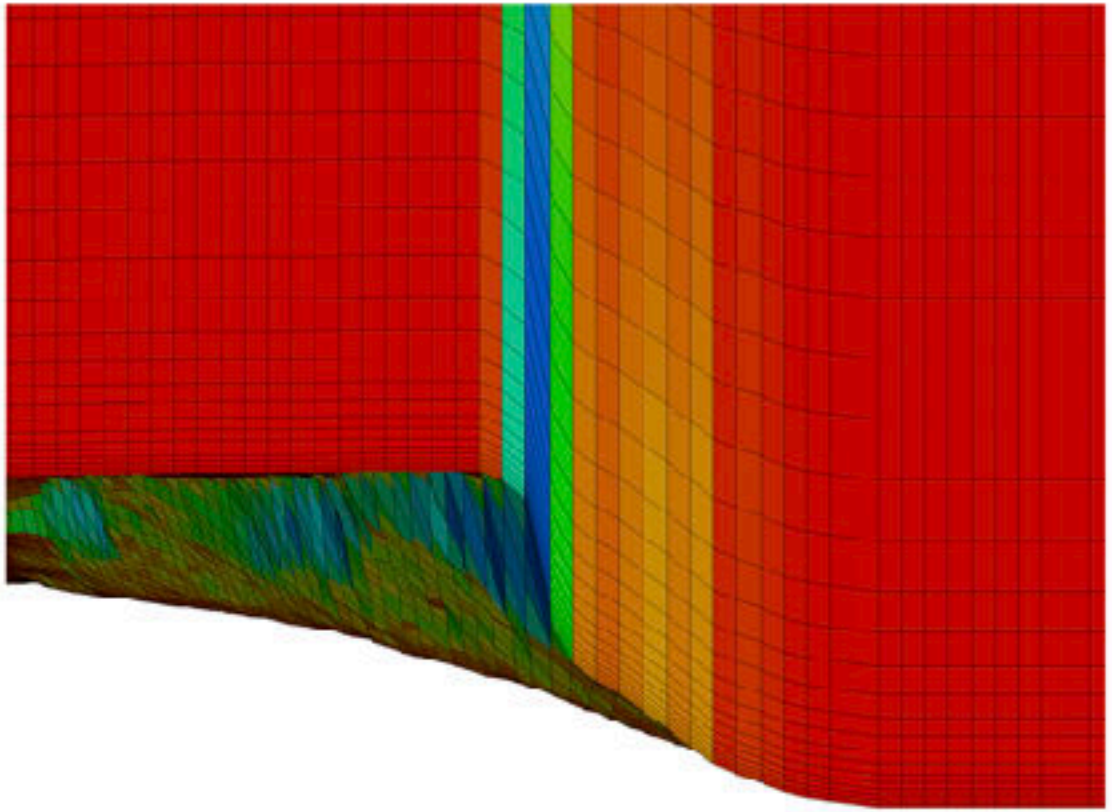
2. Quadrilateral surface mesh

- Structured mesh (can be aligned with the inflow wind direction)
- Mesh optimization

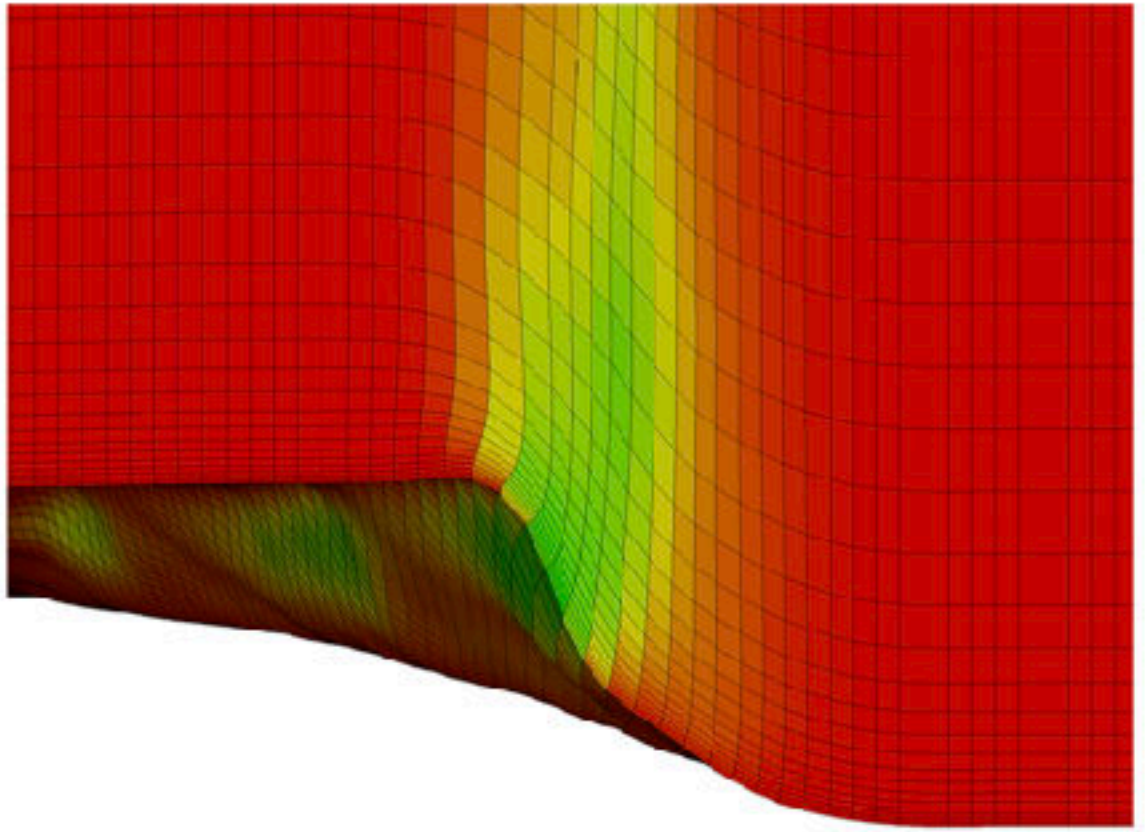
3. Hexahedral volume mesh

- Structured sweeping mesh (can be aligned with the inflow wind direction)
- Mesh optimization

Iberdrola - Preprocesing - mesh generation



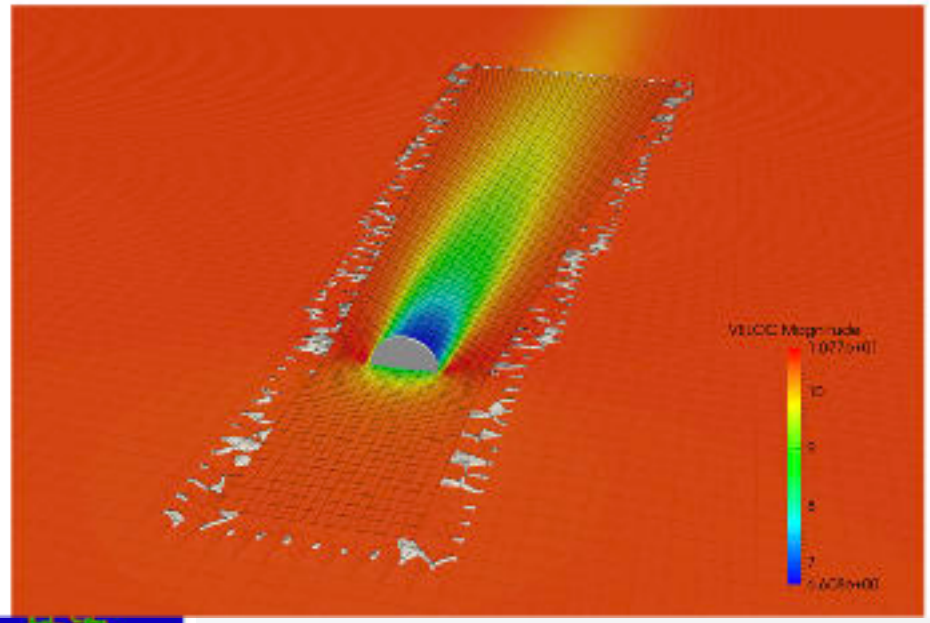
Mesh generation extruding in the vertical direction without mesh optimization



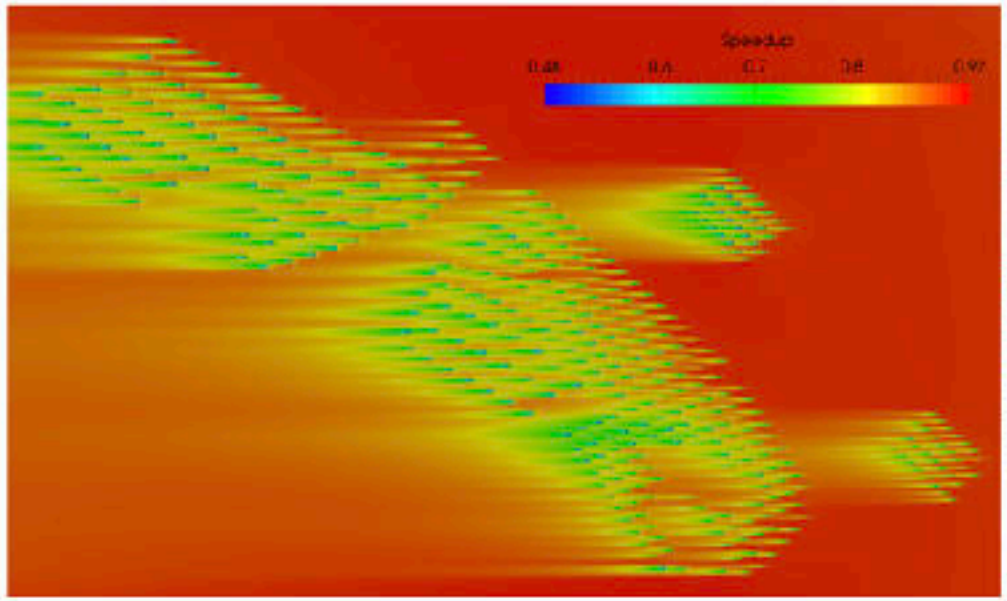
Mesh generation using the pseudo-normal mesh optimization (colours indicate the quality of the resulting hexahedral elements). Note how the boundary layer is preserved

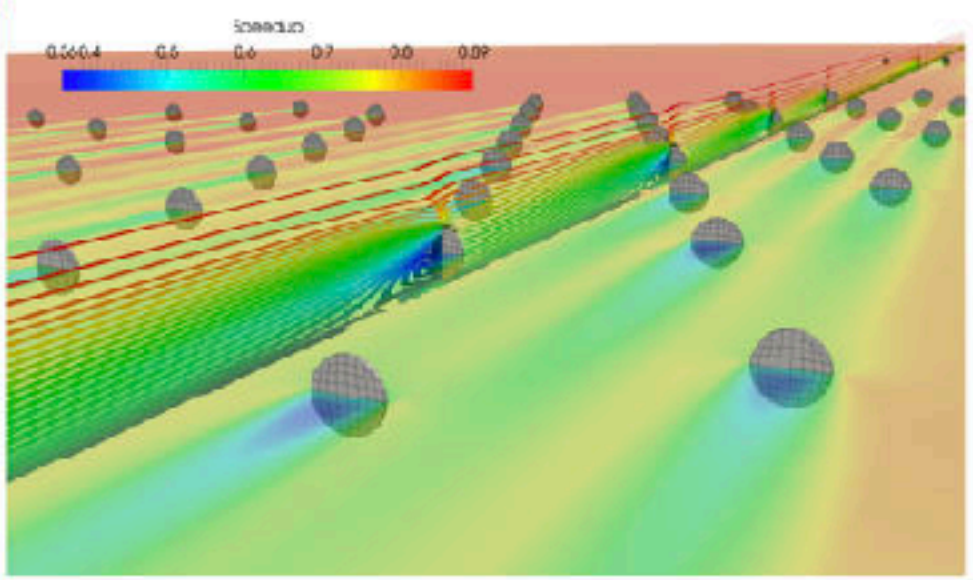
Iberdrola - DiscMesh: mesh generation for wind farms

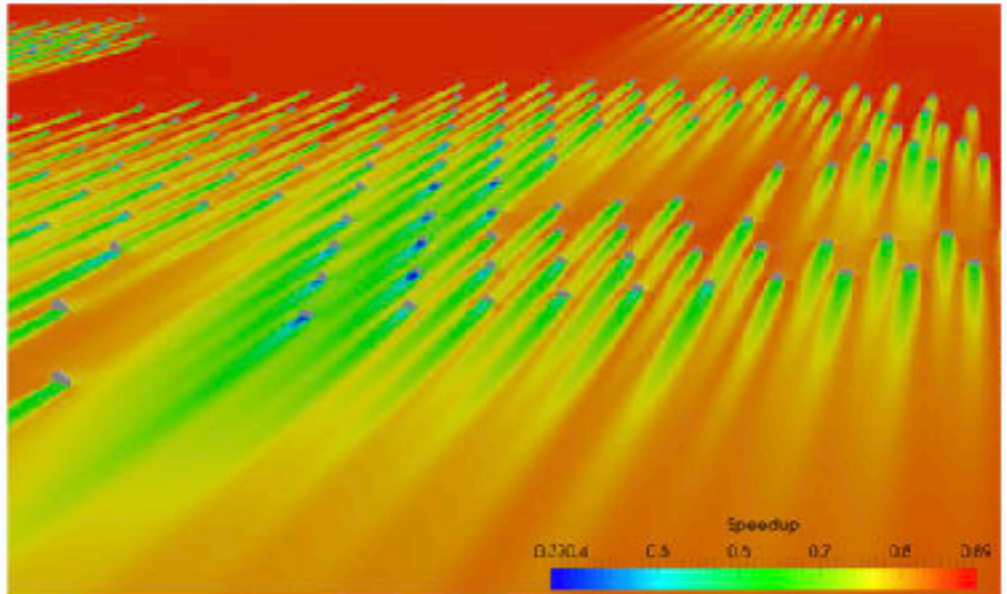
- DiscMesh generates unstructured hybrid meshes for wind turbines and does embedding in a background mesh (generated by WindMesh)
- Downstream element refinement for wake capturing

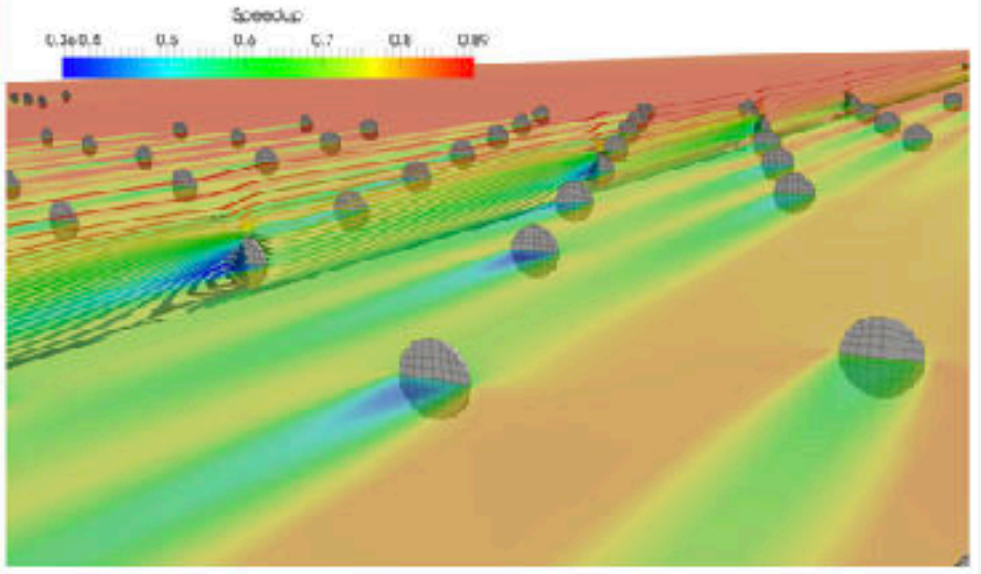


Iberdrola - Wind farm modelling









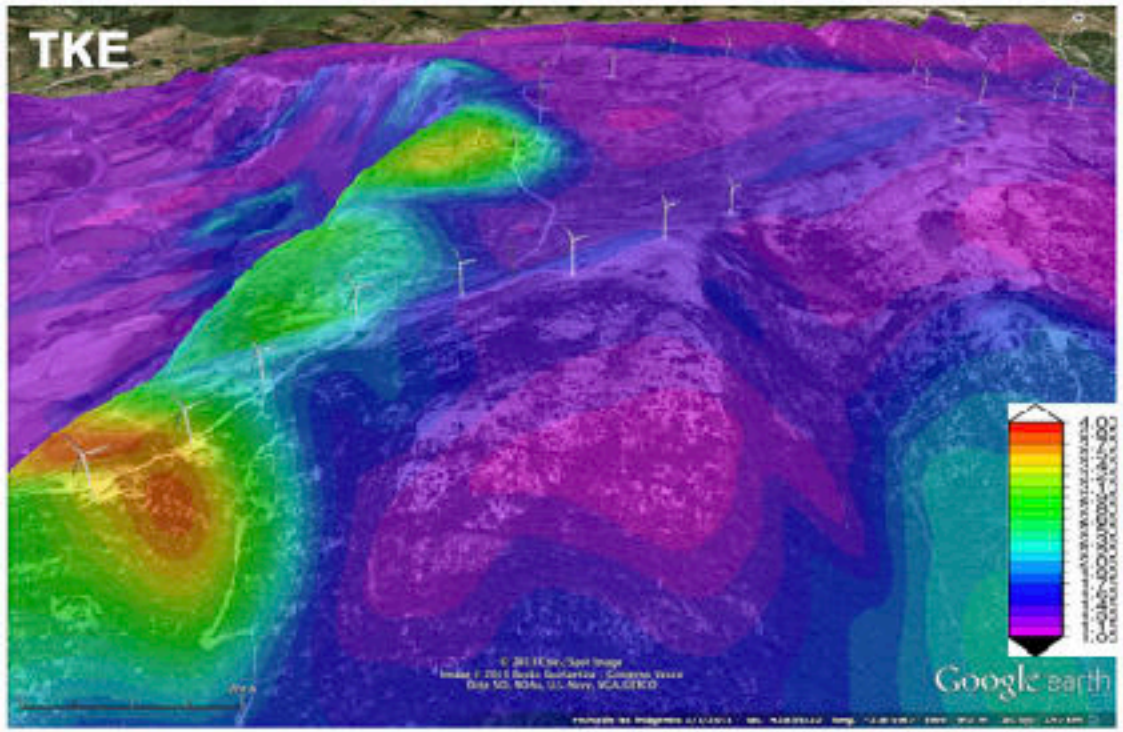
West of Duddon Sands (WoDS, U.K.) off-shore wind farm modelling using Alya

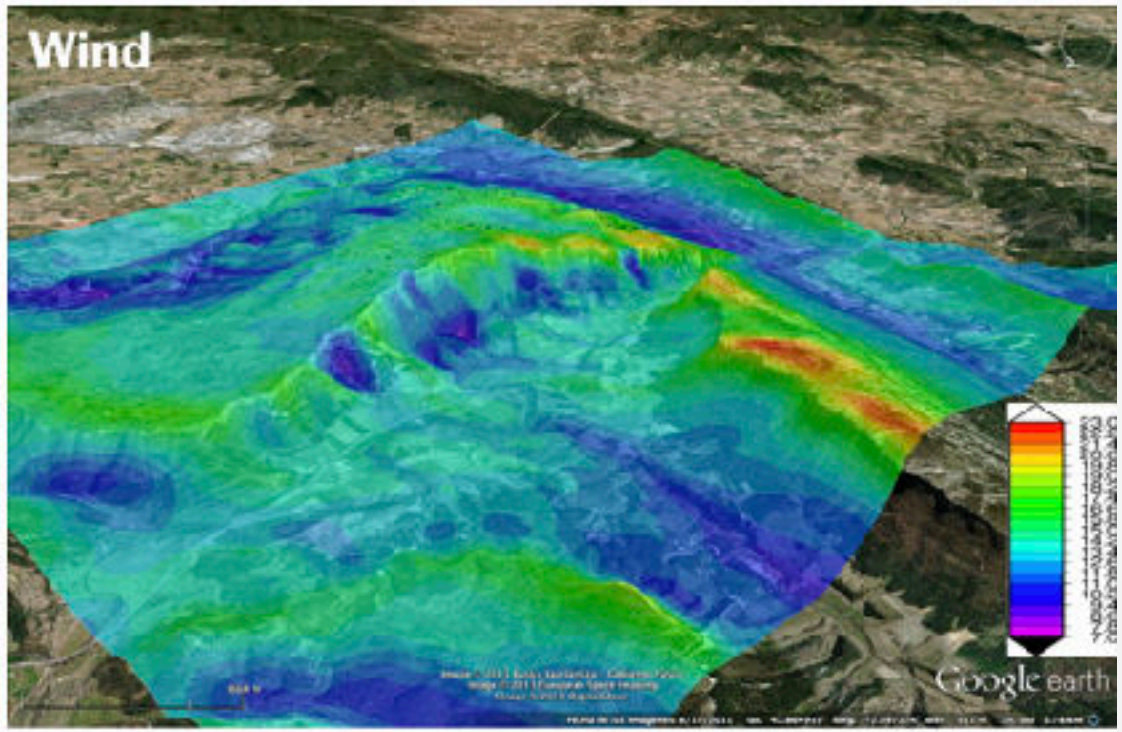
Iberdrola - Wind farm modelling

Post-process tools for wind resource assessment and visualization:

- Wind fields
- Site Weibull distributions
- Turbulence intensity
- Annual Energy Production (AEP)

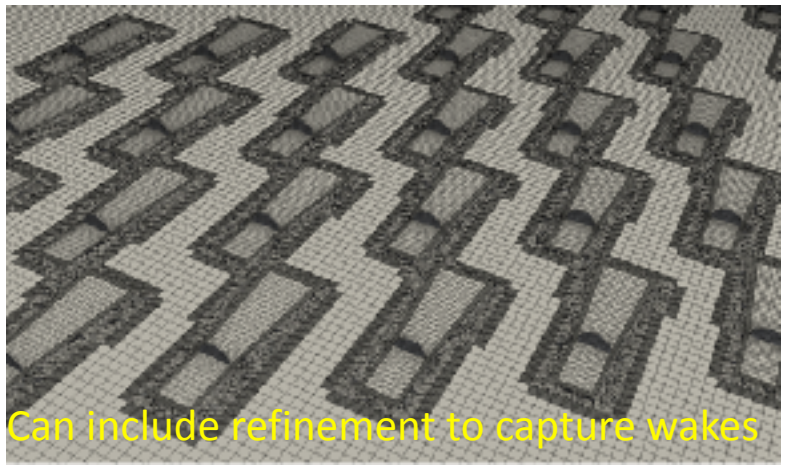
Automated methodology and visualization using Google Earth layers





Wind Farm Modelling - Alya Workflow

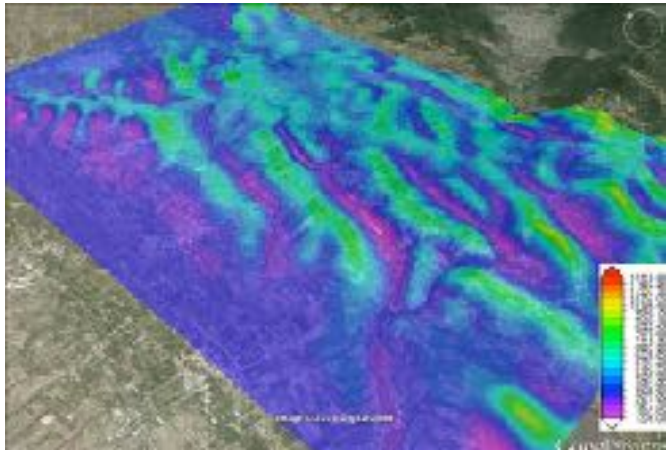
WindMesh inputs:
Topography and roughness files (grd, map, etc) +
wind farm location + ..



AlyaFix. Boundary conditions with minimal user input:
Latitude + Geostrophic wind + ..

Run ALYA in supercomputer

PostFarm. Obtain WRG file with Weibull parameters A & k + Visualisation of results in Google Earth or Paraview

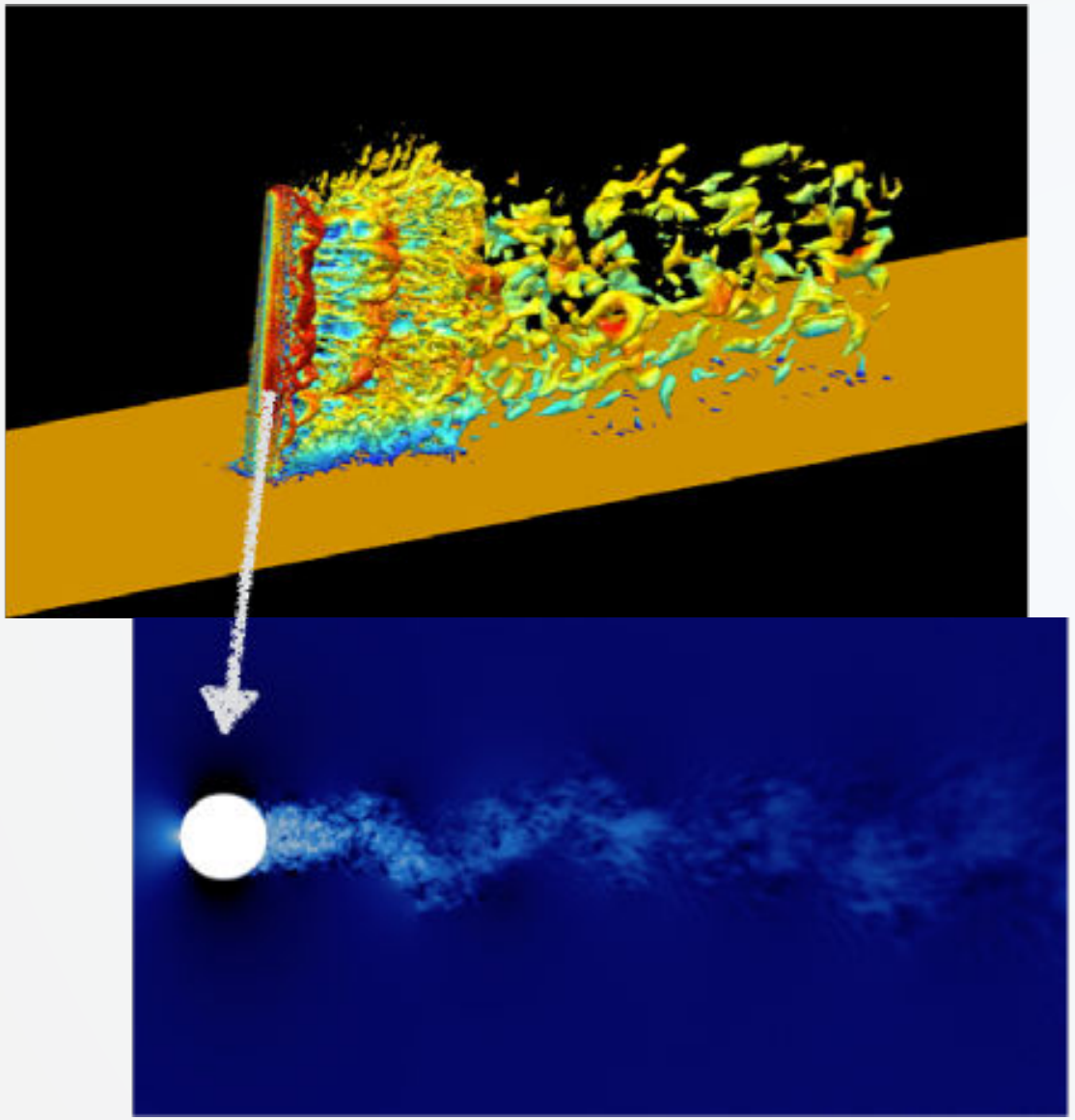


Developed for

IBERDROLA

Used by them as an alternative to comercial tools

Vortex Bladeless - an SME



Scale-up assessment of the Vortex-Bladeless device
Optimisation of the device at the aero-elastic level
Fluid Structure Interaction problem

Within the framework of a H2020 SME Instrument for Vortex Bladeless S.L. and a PRACE SHAPE project

PRACE SHAPE
SME HPC Adoption Programme in Europe

This project is funded by the European Union

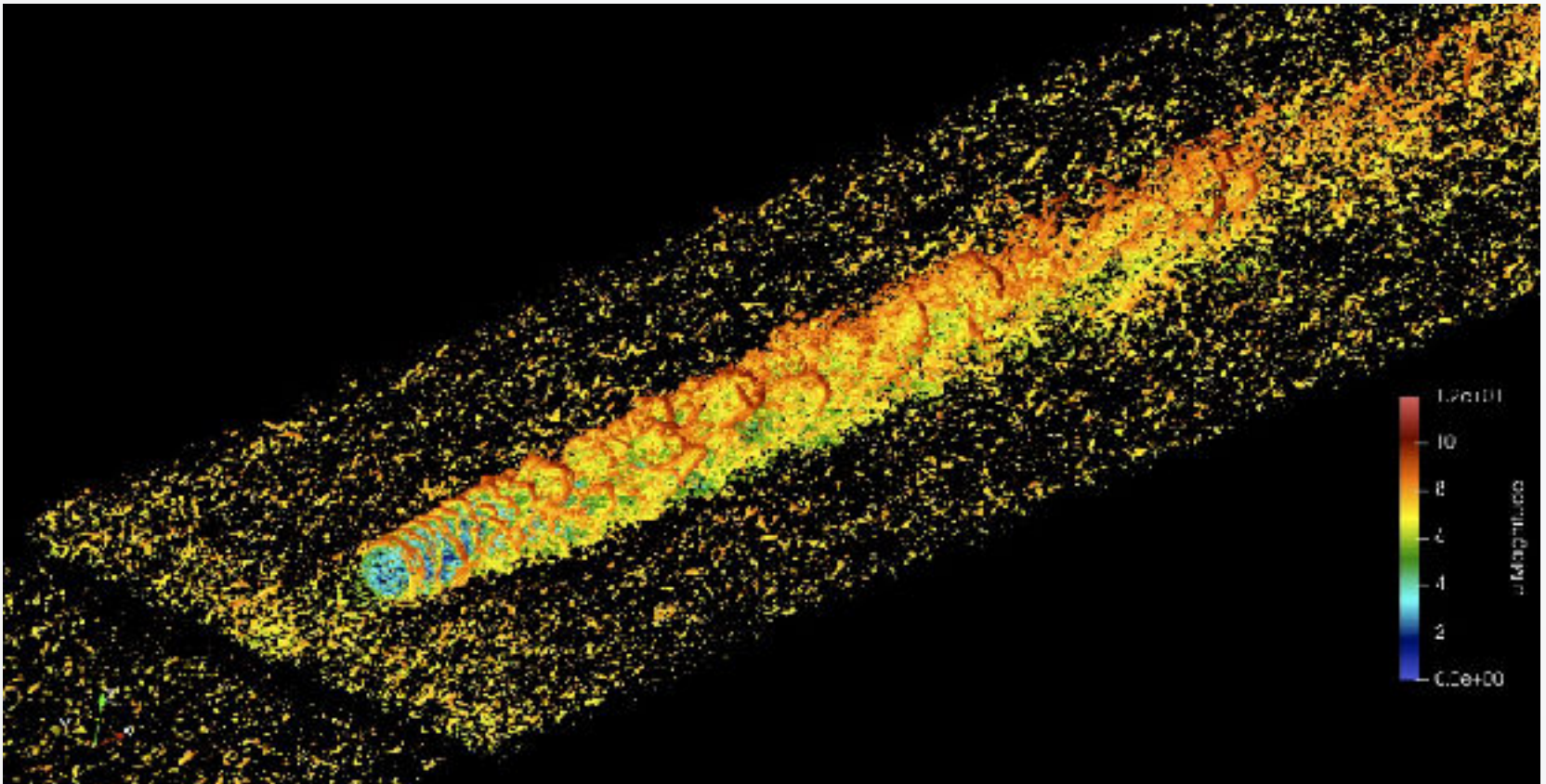
VORTEX Bladeless

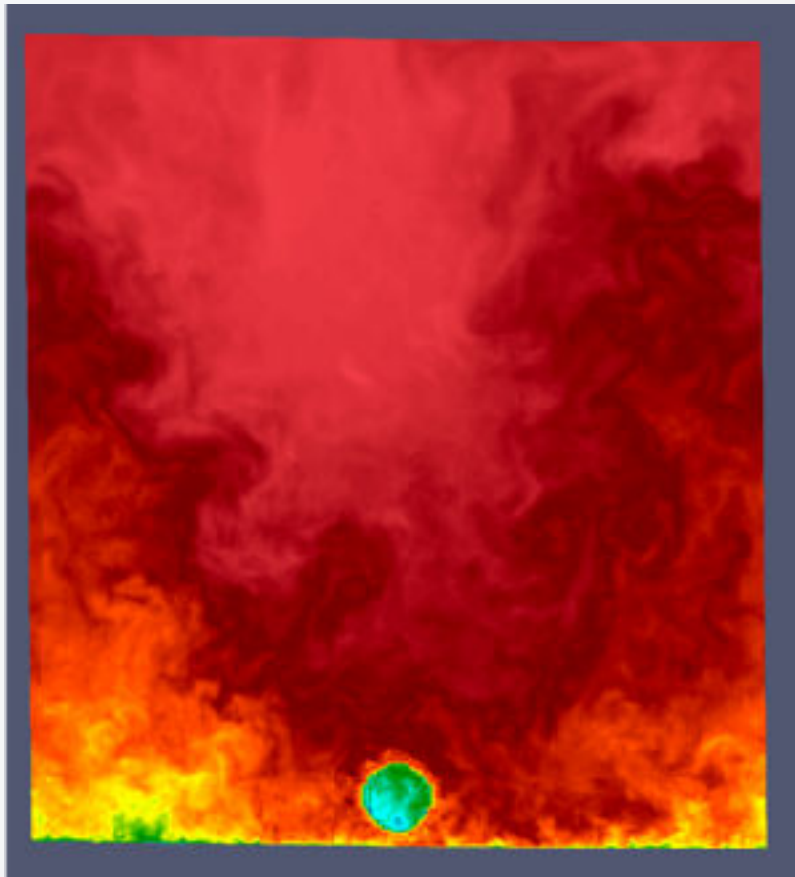
OceanWinds

OW OCEAN WINDS

Joint venture between **Engie and EDP**.

Starting new collaboration on Scale Resolving Simulations for Offshore Wind energy using **SOD2D**





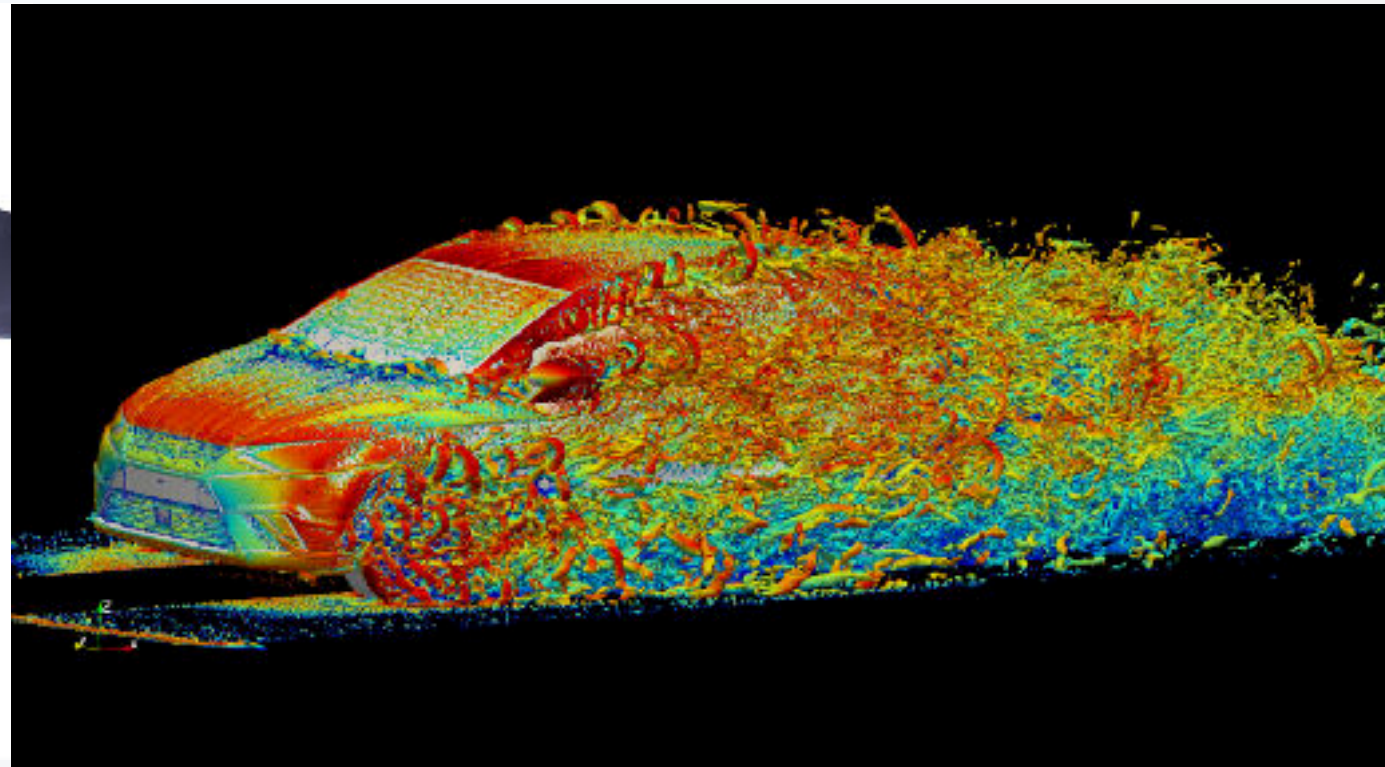
Other big companies

AIRBUS

WMLES as an alternative to RANS for aircraft aerodynamics

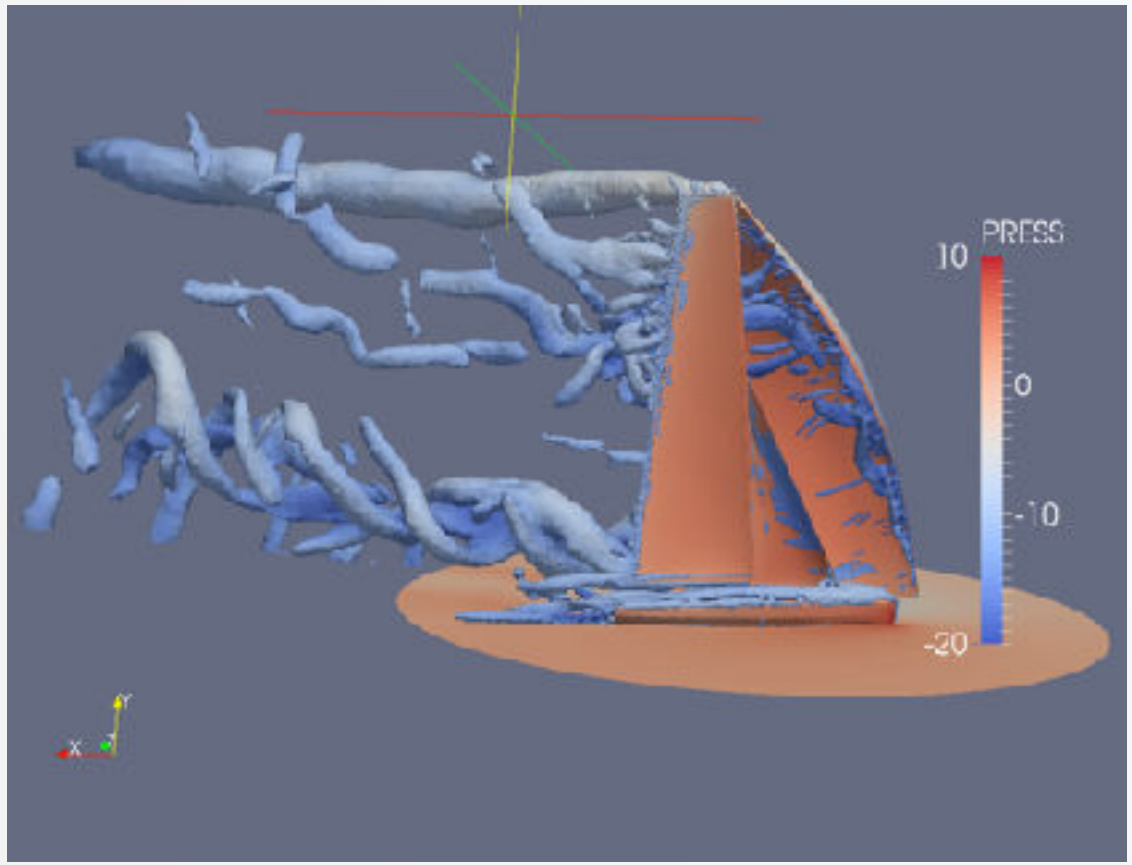
SEAT

WMLES for automotive aerodynamics - rotating wheels

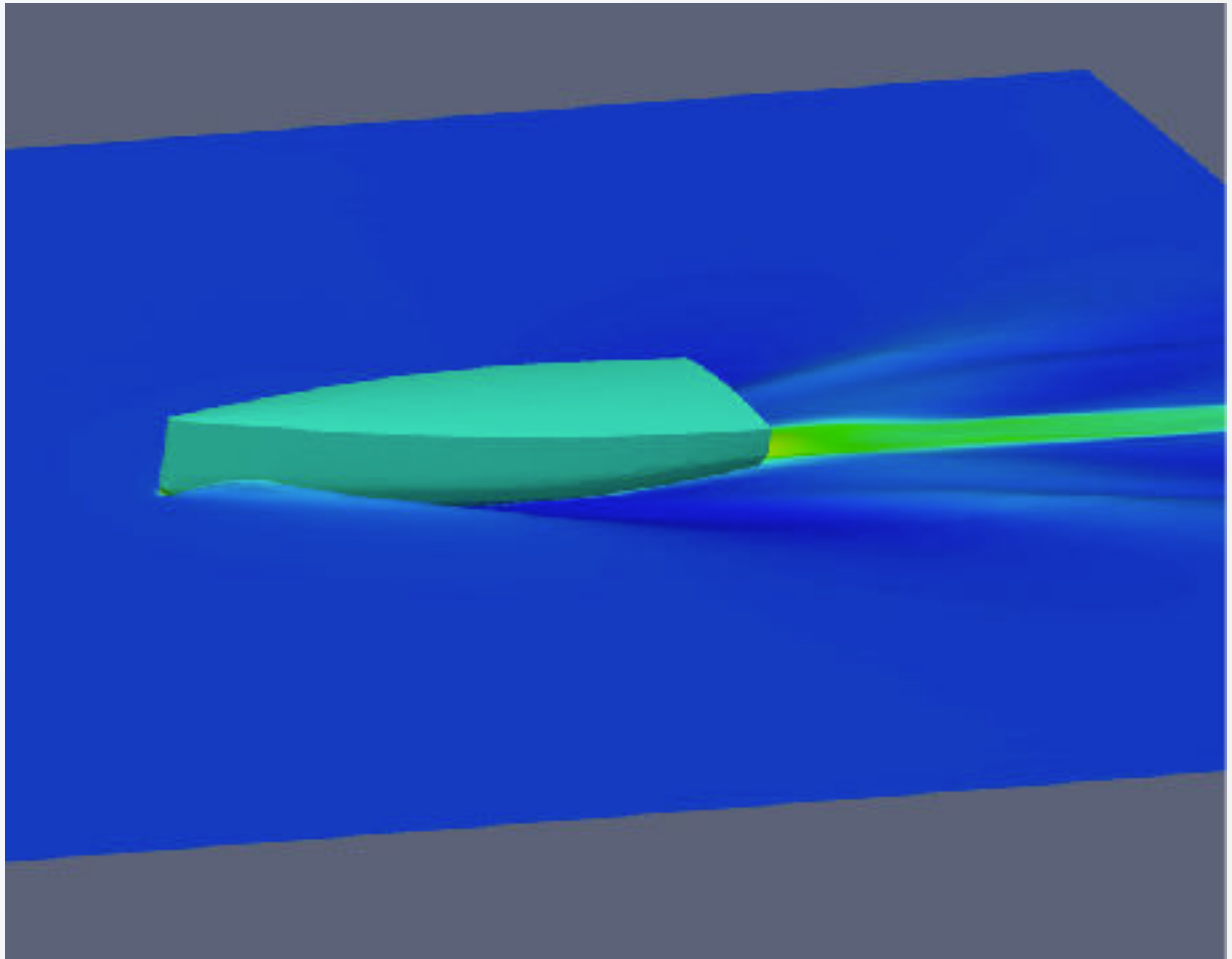


Other small companies - Juan Yatch Design

RANS vs LES for boat aerodynamics



Free Surface flow & mesh deformation



Thank you for your attention!