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LES on wind turbines by comparaison of Vortex Particles Method and Finite Volume Method codes

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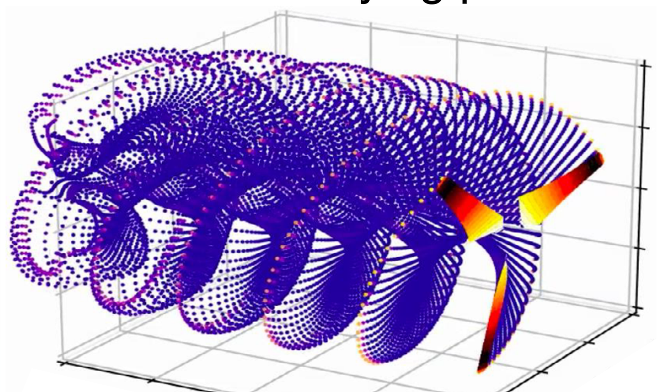
MOTIVATIONS

- Increasing wind energy requires a growing computational effort
- Several numerical models are used for wind turbine wakes and performance assessment
- Thus, two different **codes are compared for blade loads and wake quantities**

COMPARISON

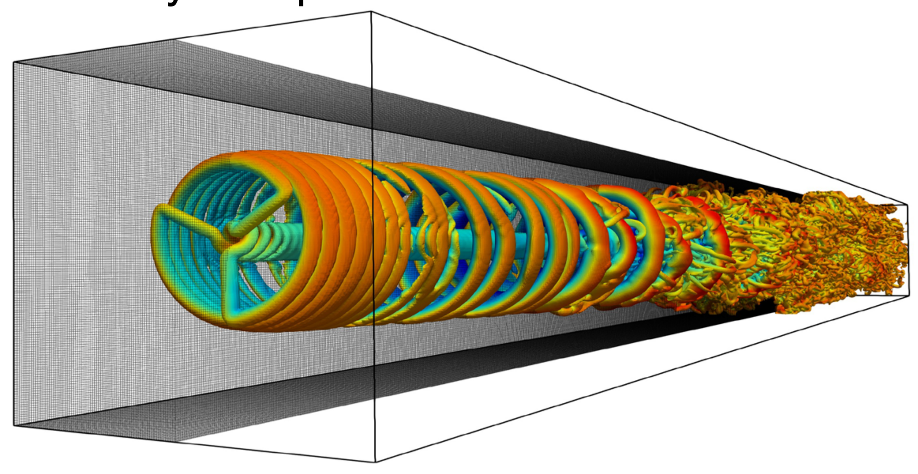
Vortex Particle (VP) method: Dorothy [2]

- **Unsteady Lagrangian method**
- Particles carrying position and vorticity



Finite Volume (FV) method: YALES2 [3]

- **Unsteady Eulerian Method**
- Velocity and pressure are stored at nodes



Fluid equations (Incompressible Navier-Stokes equation)

Velocity-vorticity formulation

$$\nabla\cdot\tilde{u}=0,$$
$$\nabla\times\tilde{u}=\tilde{\omega},$$
$$\frac{\partial\tilde{\omega}}{\partial t}+(\tilde{u}\cdot\nabla)\tilde{\omega}=(\tilde{\omega}\cdot\nabla)\tilde{u}+\nabla\nu_T\times\Delta\tilde{u}+(\nu+\nu_T)\Delta\tilde{\omega}$$

Velocity-pressure formulation

$$\nabla\cdot\tilde{u}=0,$$
$$\frac{\partial\tilde{u}}{\partial t}+(\tilde{u}\cdot\nabla)\tilde{u}=-\nabla\tilde{P}+\nu\nabla^2\tilde{u}+\nabla\cdot\tilde{\tau}^M+f$$

Rotor modeling

Lifting-Line (LL) | **Actuator Line** (AL)

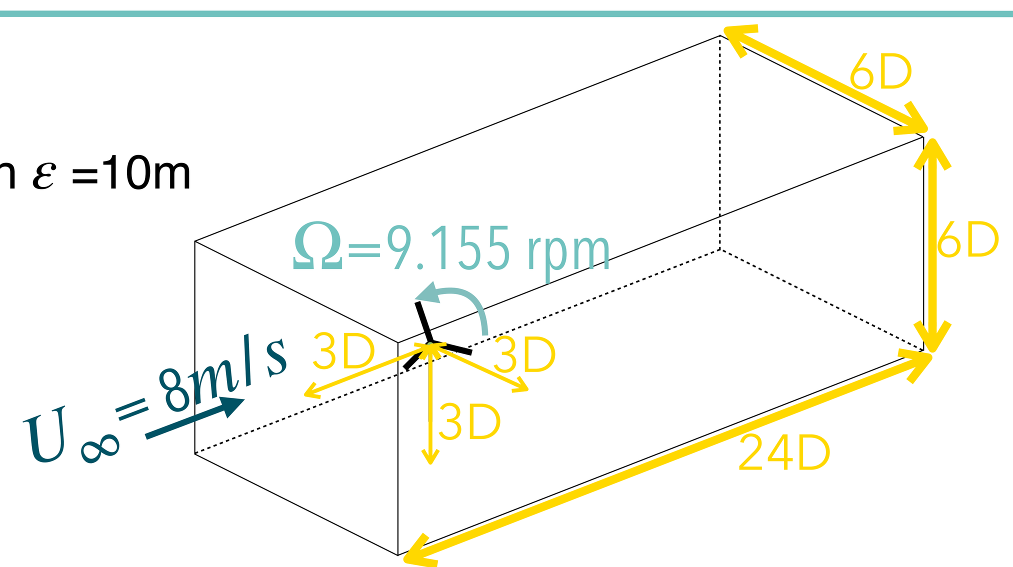
Discretisation

Lifting-Line (LL):
- 32 points per blade
- ε → applied on fluid equations = cut-off distance: 2.88m, 3.84m, 10m
- Particles size (depends on ε value): 1.92m, 2.56m, 6.67m
- Function: **MR** and **WL** regularised Biot-Savart kernel

Actuator Line (AL):
- 64 points per blade
- ε → applied on rotor modeling = smeared forces distance: 3.84m, 10m
- Wake on mesh discretization: 1.96m
- Function: **Gaussian** mollification

CONFIGURATION

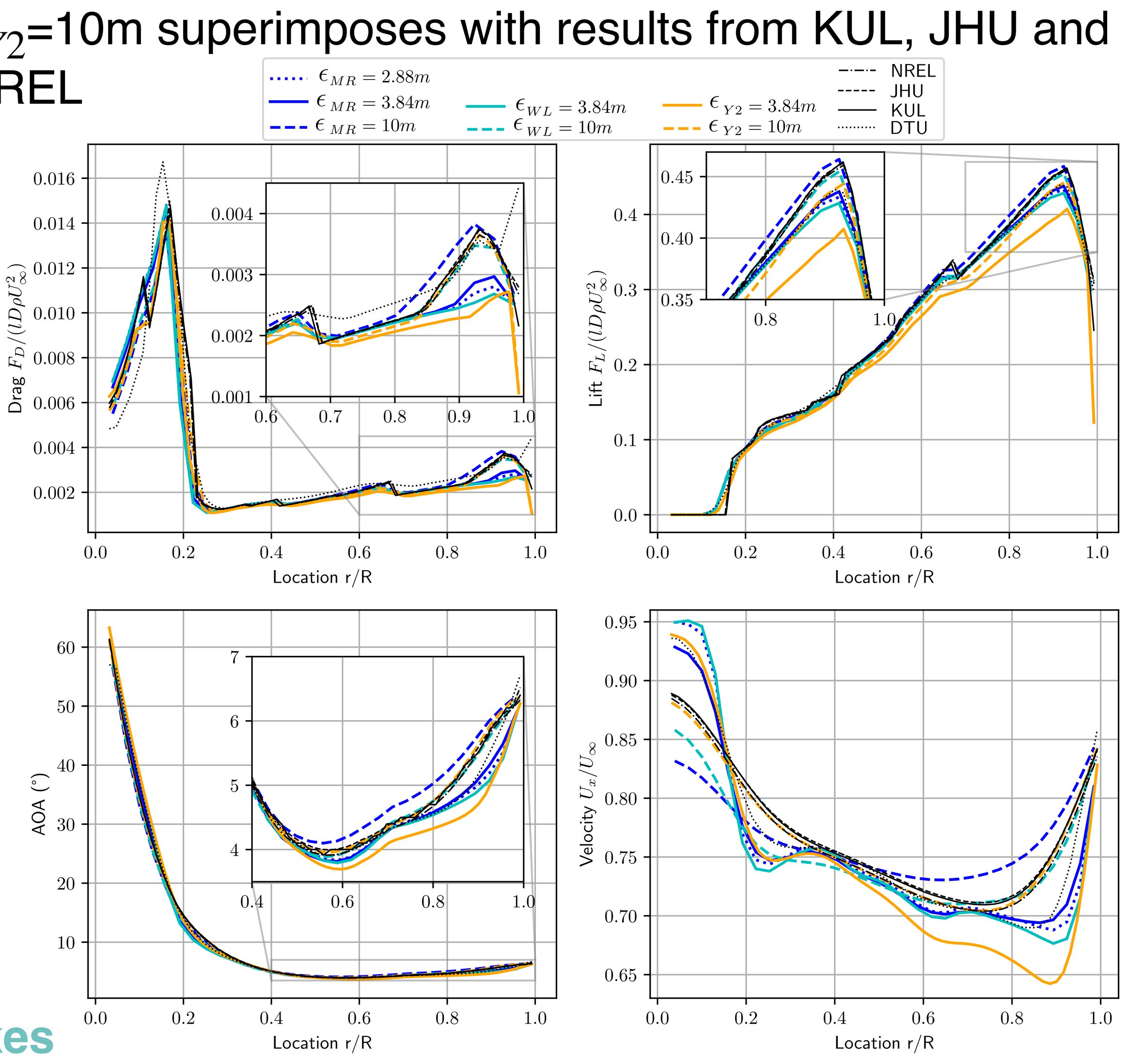
- Set-up from Martinez-Tossas [1] with ε =10m
  1 x **NREL 5MW** (D=126m)
- Laminar inflow



VERIFICATION

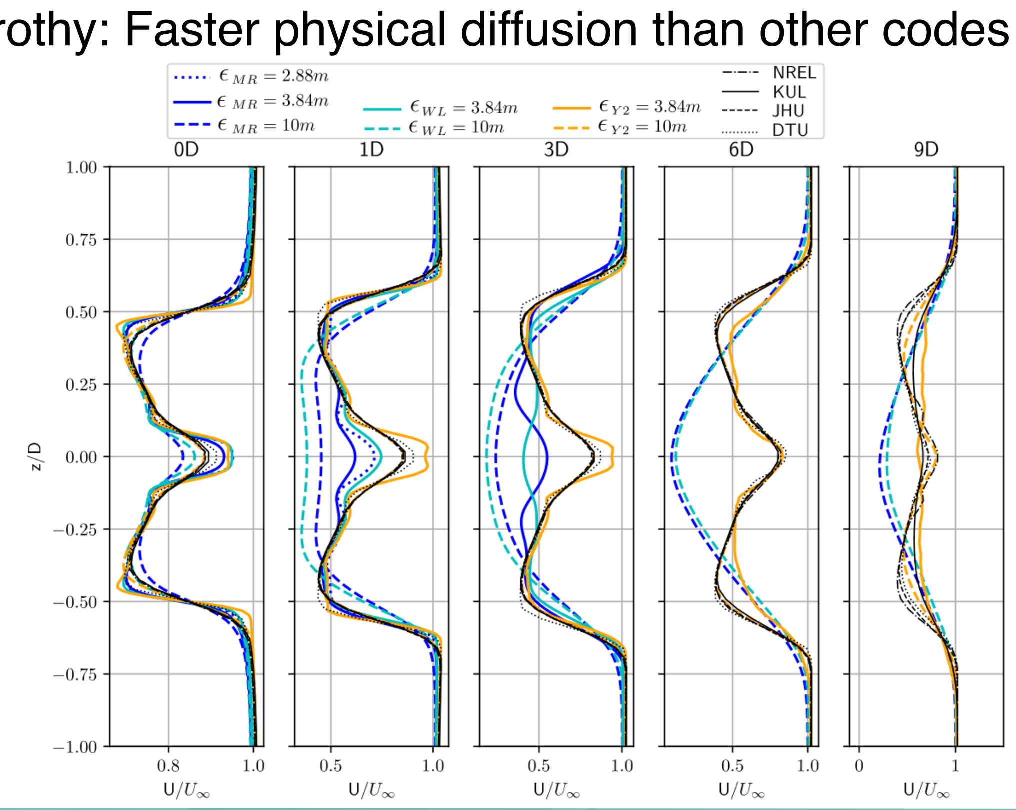
Loads

- Similar value for ε_{MR} =2.88m, ε_{WL}=3.84m and DTU
- ε_{Y2}=10m superimposes with results from KUL, JHU and NREL



Wakes

- YALES2: Behaviour similar to other codes
- Dorothy: Faster physical diffusion than other codes



CONCLUSION

Loads

- Identical behaviour for radial loads
- Lower ε affects in the same way on LL-VP and AL-FV => more accurate results

Wakes

- ε affects wake resolution for LL-VP only
- Lower ε trigger wake instability earlier for AL-FV only

PERSPECTIVES

- Compare computational cost of Dorothy and YALES2 for multi turbines cases
- Perform a longer simulations with Dorothy for the wake comparison
- Analyse both codes with turbulent inflow cases

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