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

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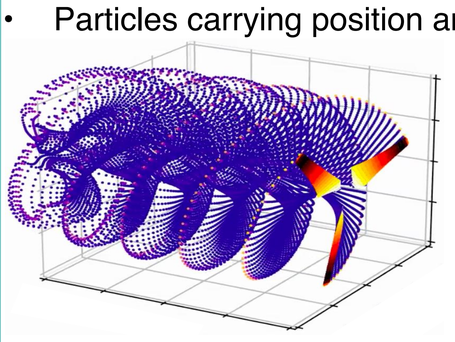
MOTIVATIONS

- 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

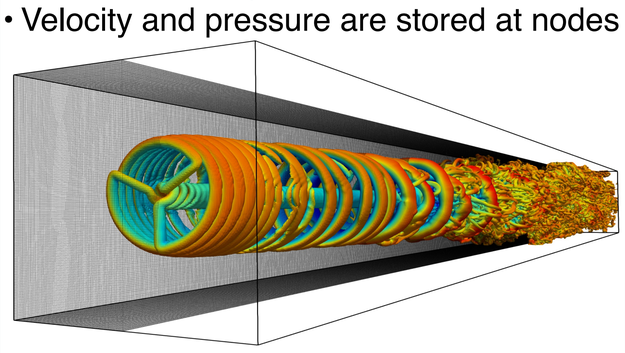
Vortex Particle (VP) method: Dorothy [2]

- **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

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

Velocity-pressure formulation

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

Rotor modeling

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

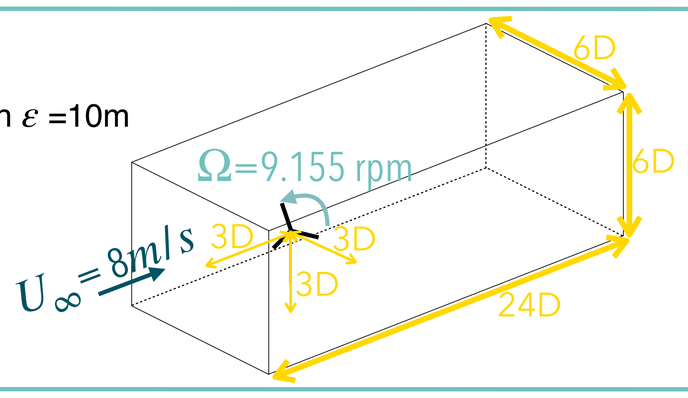
Actuator Line (AL)

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

Discretisation

CONFIGURATION

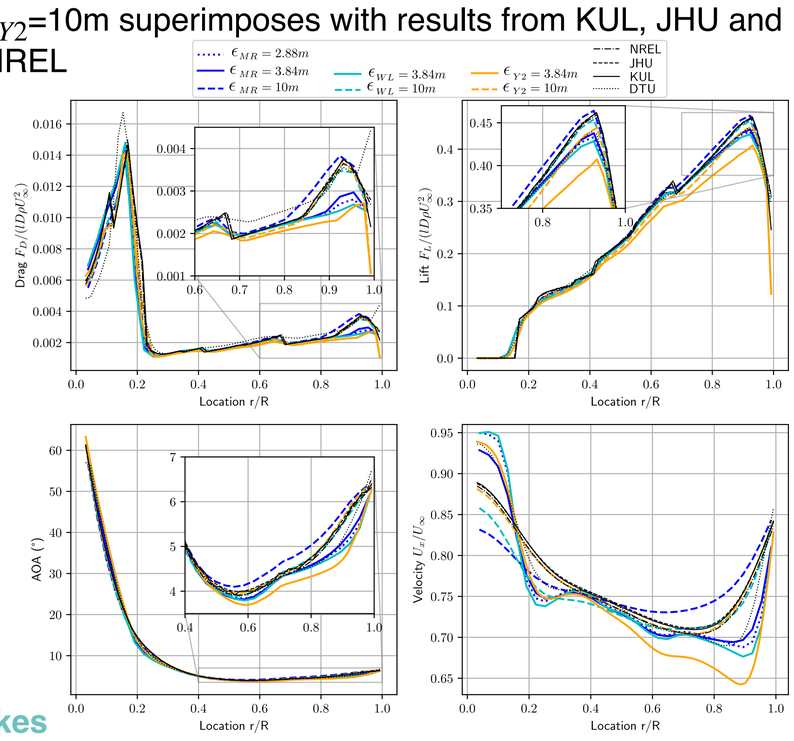
- Set-up from Martinez-Tossas [1] with ε =10m
  1 x **NREL 5MW** (D=126m)
- Laminar inflow



VERIFICATION

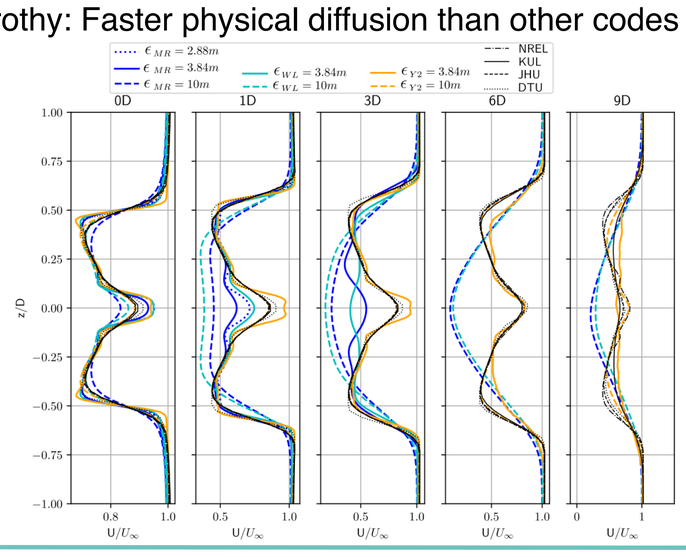
Loads

- 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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