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Poster n°6

Coupling steady-state wake models with floater hydrostatics for floating offshore wind farms

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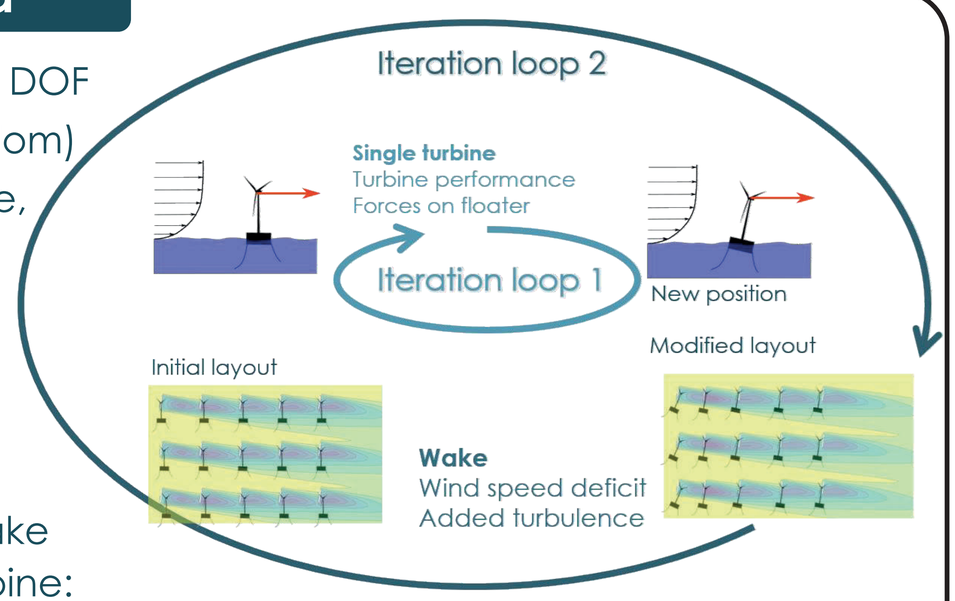
Context and objectives

Accounting for the effect of floater position on the production and fatigue

- ✓ Considering aerodynamic, hydrostatic and mooring load to compute average floater position
- ✓ By coupling hydrostatic and wake modelling tools

Method

Rigid floater with 6 DOF (Degrees Of Freedom) surge, sway, heave, roll, pitch, yaw

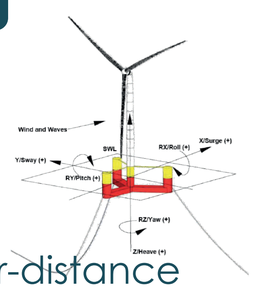


Build farm
Compute wake
For each turbine:
loop 1: Compute aero loads for averaged wind on rotor
loop 1: Update floater position (static computation)
Update farm layout
loop 2

Application example

Virtual wind farm:

- ✓ 25 IEA 15MW turbines
- ✓ Semi-submersible floater
- ✓ Regular layout, 7D / 5D inter-distance



Steady-state wake models

Wake modelling tool: **FarmShadow™**

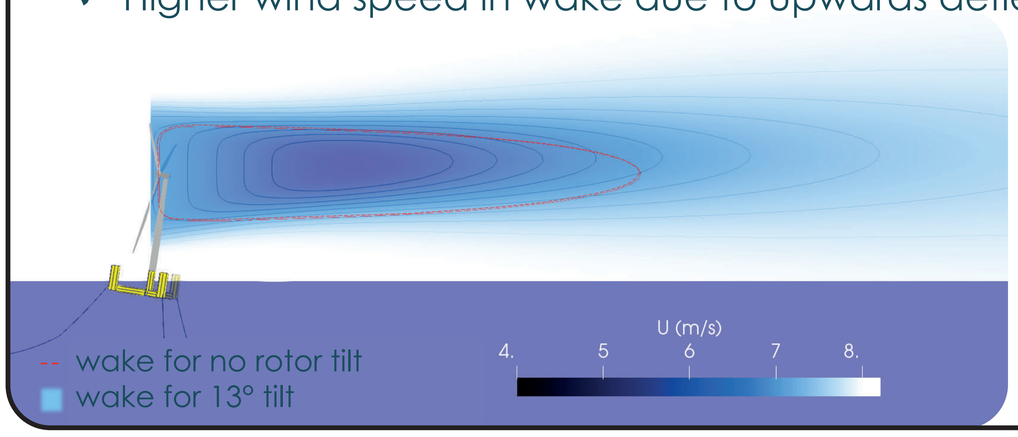
- ✓ Velocity deficit: Super-Gaussian model [1]
- ✓ Added-turbulence model [2]
- ✓ Superposition: local linear sum model
- ✓ Wake deflection model [3], adapted from yaw to tilt angle.

Results

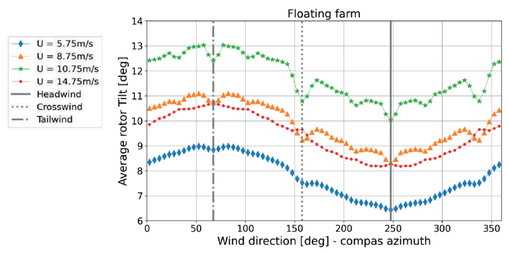
Surge and Sway have no substantial effect on wake.

Roll and Pitch lead to **rotor tilt** with two opposing effects:

- ✓ Lower output power for underrated wind.
- ✓ Higher wind speed in wake due to upwards deflection.



Rotor tilt variation with wind speed and direction (shaft tilt: 6°)

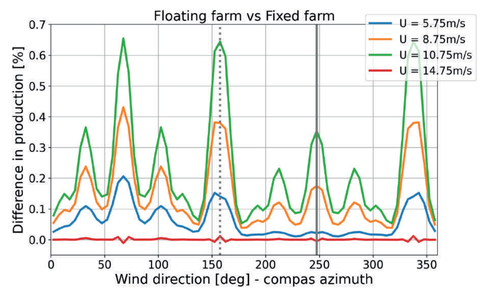


Simplified turbine performance curves (C_p, C_t) considering:

- ✓ Wind speed
- ✓ Fixed wind vertical shear
- ✓ Fixed wind direction
- ✓ No waves

Annual Energy Production (AEP) for floating farm (vs. fixed):

- ✓ -0.32% due to the floater position
- ✓ +0.07% due to wake upward deflection



Conclusions and perspectives

The **upwards wake deflection** due to floater pitch and roll:

- ✓ has a small impact on production
- ✓ could affect the turbine structural fatigue

Dedicated workflow to efficiently compute AEP for floating wind farms to be developed through the **Joint Industrial Project FAME**.
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1. Blondel, F., Cathelain, M. (2020). "An alternative form of the super-Gaussian wind turbine wake model". Wind Energy Science, 5(3)
2. Ishihara, T., Qian, G. W. (2018). "A new Gaussian-based analytical wake model for wind turbines considering ambient turbulence intensities and thrust coefficient effects". Journal of Wind Engineering and Industrial Aerodynamics, 177, 275-292.
3. Qian, Guo-Wei; Ishihara, Takeshi (2018) A New Analytical Wake Model for Yawed Wind Turbines. In : Energies, vol. 11, n° 3, p. 665.

Full report (D2.3, pp12-30) and references available on https://www.hiperwind.eu/publications

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