Renewable energies

Numerical simulation of an offshore wind farm

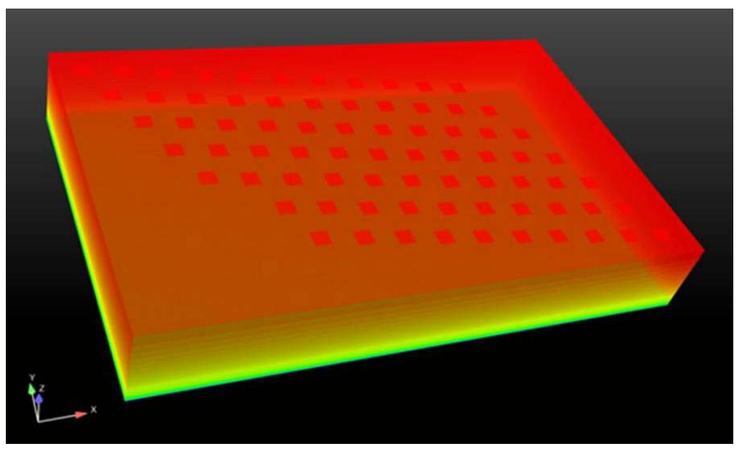
Numerical parameters sensitivity analysis

1 CONTEXT

As lead member of the consortium chosen in 2012 by the French government to build 1.5 GW of offshore wind farms in the Atlantic and English Channel, EDF group participates in the emergence of a new industry. In this context, EDF-R&D works on the accurate modelling of wake losses. The figure below shows the methodology used to estimate the Annual Energy Production for one offshore wind farm.

Methodology of the simulation of an offshore wind farm

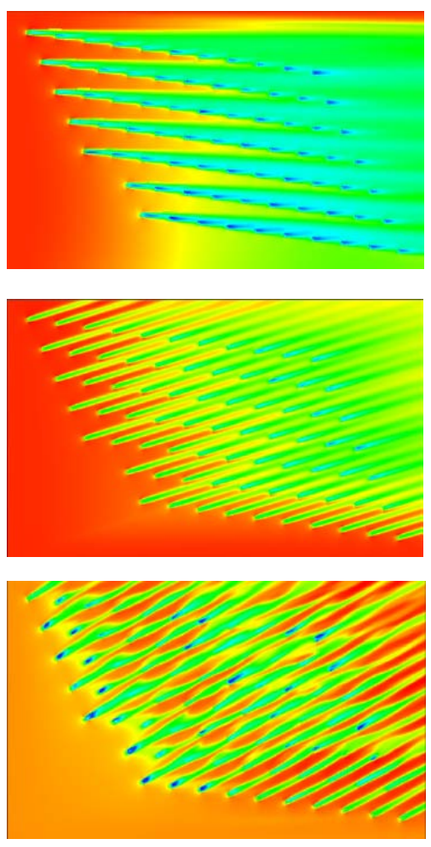
- DATA INPUT: • Mesoscale results: WRF (at least 5 data years)
- SORT: • Clustering: selection of about 100 situations
- Simulation: • Numerical simulation with *Code_Saturne* 3.0
- Results: • Estimated extraction energy for each wind turbine



Example of input and initialisation atmospheric data: wind speed

2 Numerical simulation with *Code_Saturne V3.0:*

The CFD resolution is based on the actuator disk approach for wake modelling: the thrust force is calculated with momentum theory (homogeneous approach without rotation).



Neutral

Unstable

Stable

Wind speed at hub level (for different dates)

3 Results of the numerical parameters sensitivity analysis

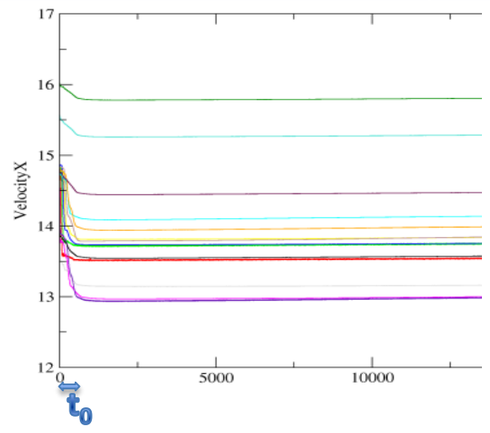
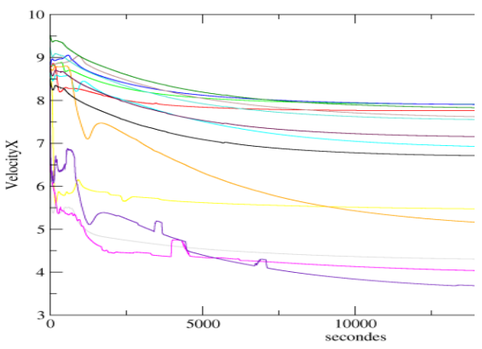
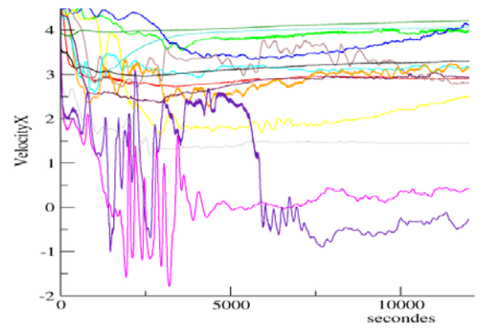
The influence of numerical parameters on three cases of different atmospheric stability: neutral, stable and unstable has been checked.

Atmospheric stability definition :

Static stability	$\partial\theta/\partial z$
Neutral	= 0
Unstable	< 0
Stable	> 0

Potential temperature
$\Theta = T(P/P_{ref})^{-R/C_p}$

The main result of this study is the influence of the atmospheric stability on the convergence time (figure below): the variable value changes during a time about ten times longer than in the neutral case for the unstable case and even more for the stable case.

Atmospheric stratification	Vx=f(t)	Convergence time
Neutral		$\times 1t_0$
Unstable		$\pm \times 10t_0$
Stable		$\times 10t_0$

4 CONCLUSION

This study shows the importance of the choice of numerical parameters to obtain an accurate result.
For atmospheric simulation, other parameters, such as turbulence models, should be tested to study the influence on the results.

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