



Norwegian University of  
Science and Technology

# A reduced order model strategy for the efficient approximation of turbulent flow around wind-turbine blades.

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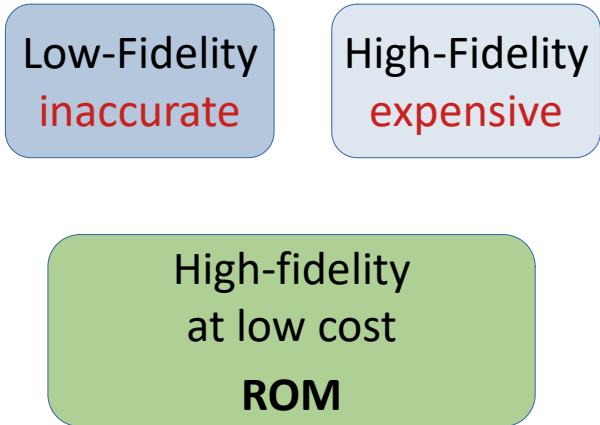
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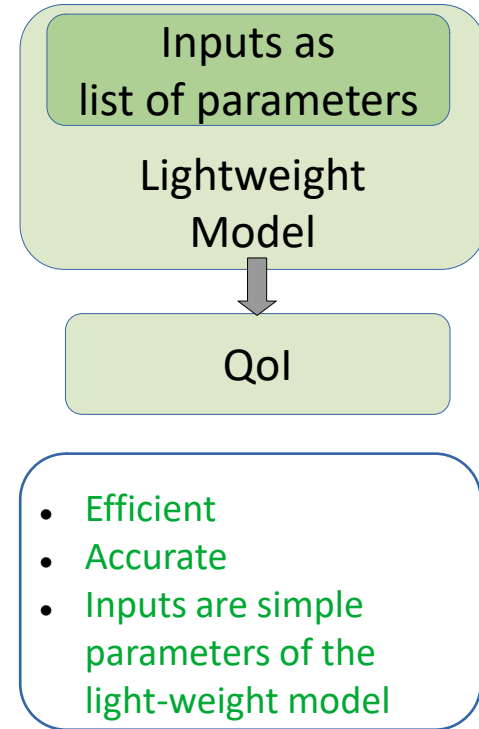
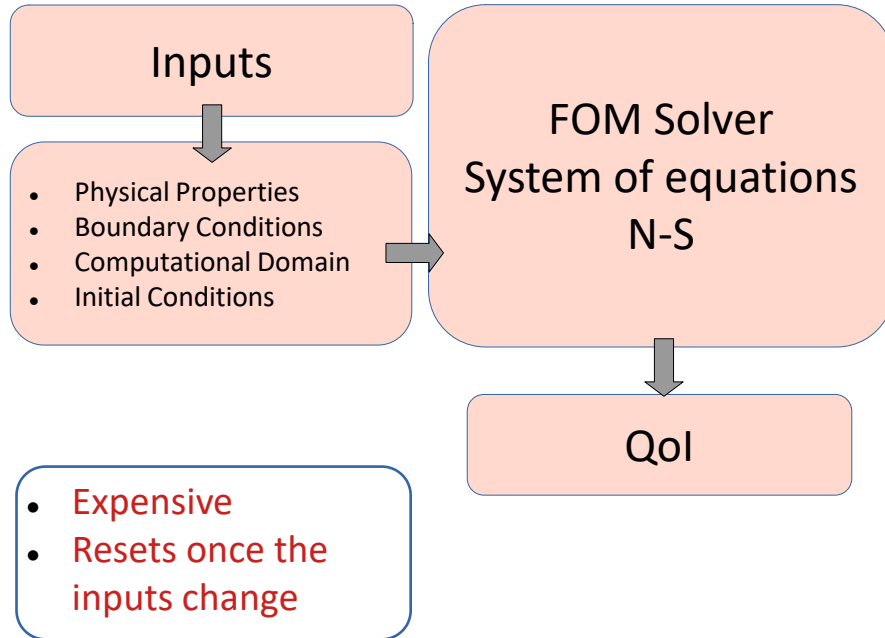
<sup>c</sup>Eindhoven University of Technology

# Model Reduction for Wind-Turbines

- ◆ Optimisation of design and operation of wind-turbines/farms
  - **Increased complexity:**
    - Accuracy and robustness.
    - Coupled problems.
    - Large number of design variations.
    - Multiple scenarios.
    - Real-time decision-making.



# Reduced Order Modelling



# Hybrid POD-Galerkin Strategy

## POD-Galerkin

Sampling of  
Full-Order Problem

Reduced Basis  
via POD

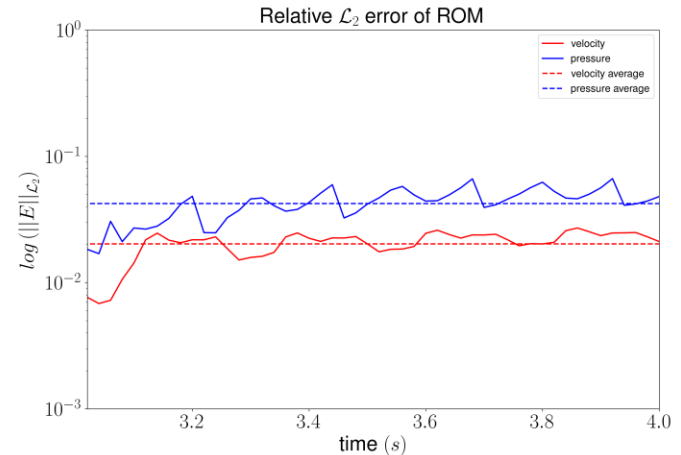
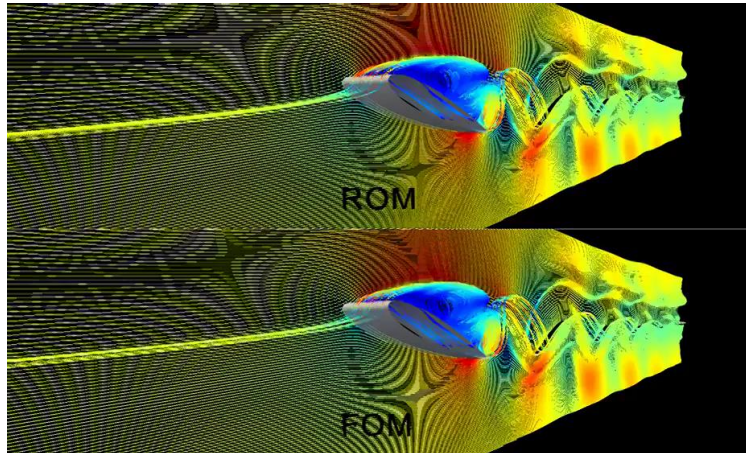
Projection of N-S  
on reduced basis

## Turbulence in the Online Phase

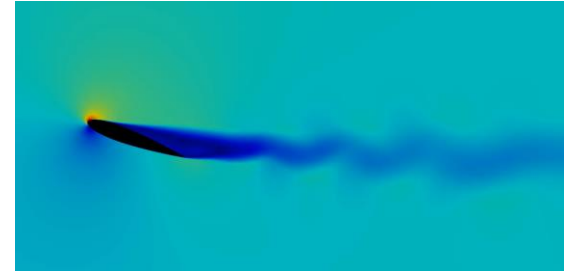
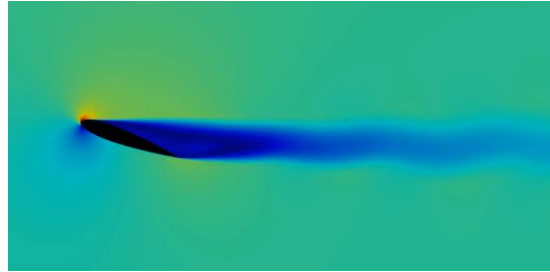
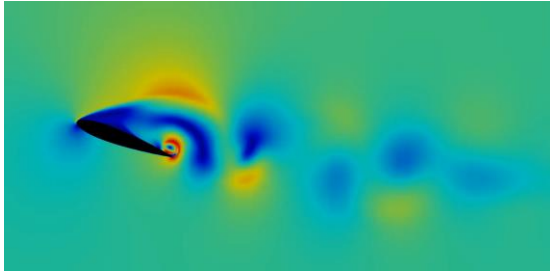
Data-Driven  
approach

Turbulence  
closure model

$Re \approx 1\,000\,000$



# Turbulent flow around an aerofoil



Reynolds number	320 000	640 000	960 000
Max error velocity	2.7 %	2.7 %	2.8 %
Avg error velocity	2 %	2.1 %	2 %

# Conclusion

- A hybrid methodology that creates more dissipative Reduced Order Models, accounting for turbulent effects.
- Applicable to industrially-relevant Reynolds numbers.
- Significant speed-up achieved over the full-order problem ( $10^4$ ), while retaining the expected accuracy.

1. V. T., T. K., A. R., E. F., H.v B., Reduced order models for finite-volume simulations of turbulent flow around wind-turbine blades. *Journal of Physics Conference Series*, 2021.
2. V. T., T. K., A. R., E. F., H.v B., A hybrid POD approach for the solution of transient turbulent flow problems. *Computer Methods in Applied Mechanical Engineering*, to be submitted.

## Acknowledgements

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