Experiments vs CFD: Who is at fault?

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Grand Opening Event, Athens, 25 January 2023

Co-funded by the European Union

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INNOVATIONS - EXCELLENCE

The flow past flatback airfoils
(with and without flow control)

Experimental Study of Drag Reduction Devices on a Flatback Airfoil

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National T

Various trailing edge drag
examined experimentally on a f
thick airfoil with 10.6% thic
measurements were performed
that the best performing devic
and reduce flow variation dow
device was a combination of the
required for the optimization of
reduction, load mitigation and

A	=	frequency amplitude
A_{max}	=	maximum frequency amplit
Cd	=	drag coefficient
Cl	=	lift coefficient
Clmax	=	maximum lift coefficient
Cp	=	pressure coefficient

Wind Energ. Sci., 5, 911–927, 2020
https://doi.org/10.5194/wes-5-911-2020

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WIND ENERGY SCIENCE

The flow past a flatback airfoil with flow control devices: benchmarking numerical simulations against wind tunnel data

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Received: 31 January 2020 – Discussion started: 12 I
Revised: 11 May 2020 – Accepted: 3 June 2020 – Publis

Abstract. As wind turbines grow larger, the use of flatback airfoils has
region of the blades. Flatback profiles provide higher lift and reduced sens
drag values. A number of flow control devices have been proposed to
profiles. In the present study, the flow past a flatback airfoil at a chord
and without trailing edge flow control devices is considered. Two differ
unsteady Reynolds-Averaged Navier Stokes (RANS) simulations and d
computational predictions are compared against wind tunnel measurem
method. The effect of each flow control device on the flow is examined

Physics of Fluids ARTICLE scitation.org/journal/phf

Investigation of the three-dimensional flow past a flatback wind turbine airfoil at high angles of attack

Cite as: Phys. Fluids **33**, 085106 (2021); doi: 10.1063/5.0055822
Submitted: 3 May 2021 · Accepted: 9 July 2021 ·
Published Online: 3 August 2021

View Online Export Citation CrossMark

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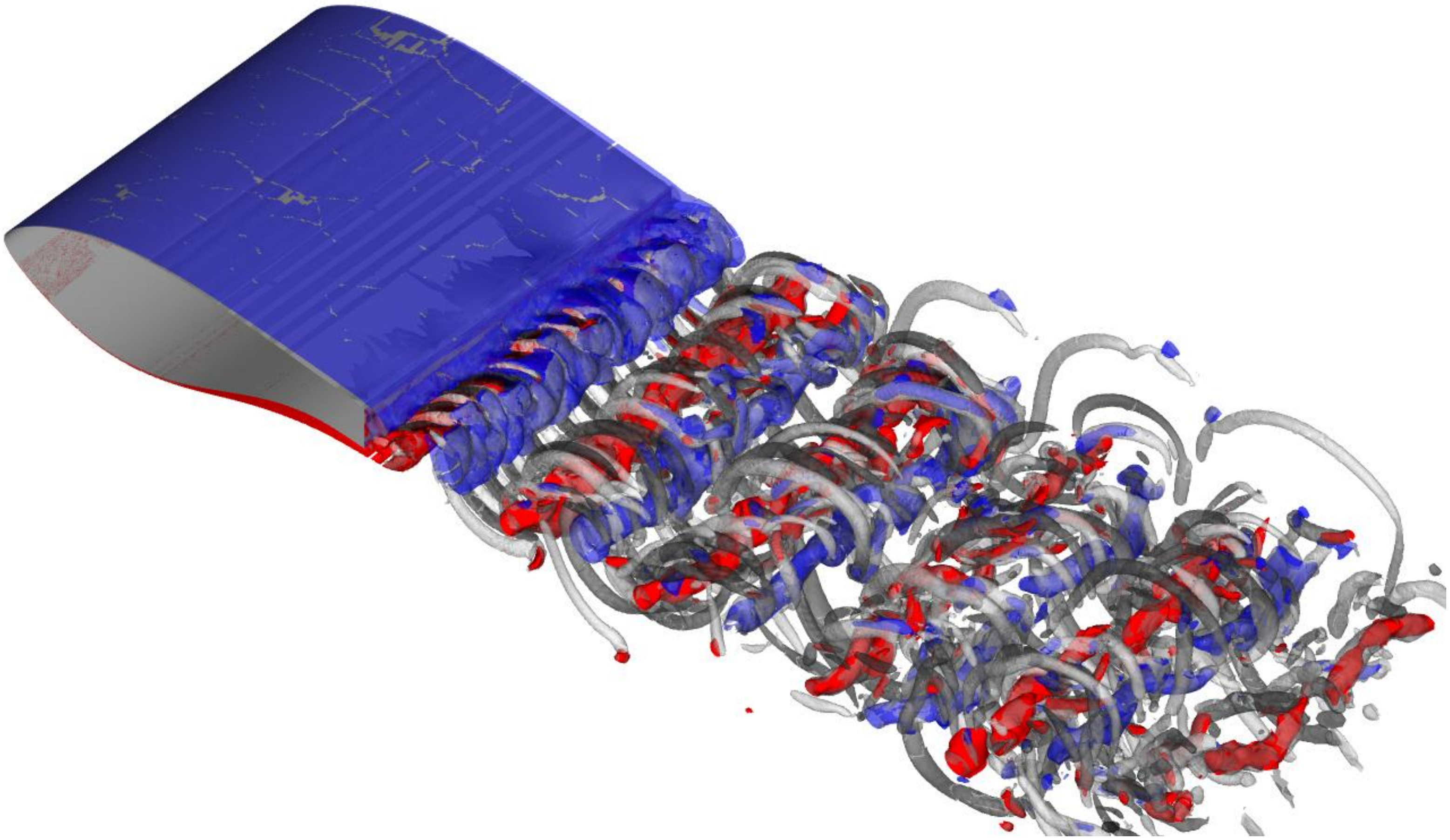
ABSTRACT
Flatback airfoils are airfoils with a blunt trailing edge. They are currently commonly used in the inboard part of large wind turbine blades, as they offer a number of aerodynamic, structural, and aeroelastic benefits. However, the flow past them at high angles of attack (AoA) has received

Challenges

3D, unsteady and unstable **wake**

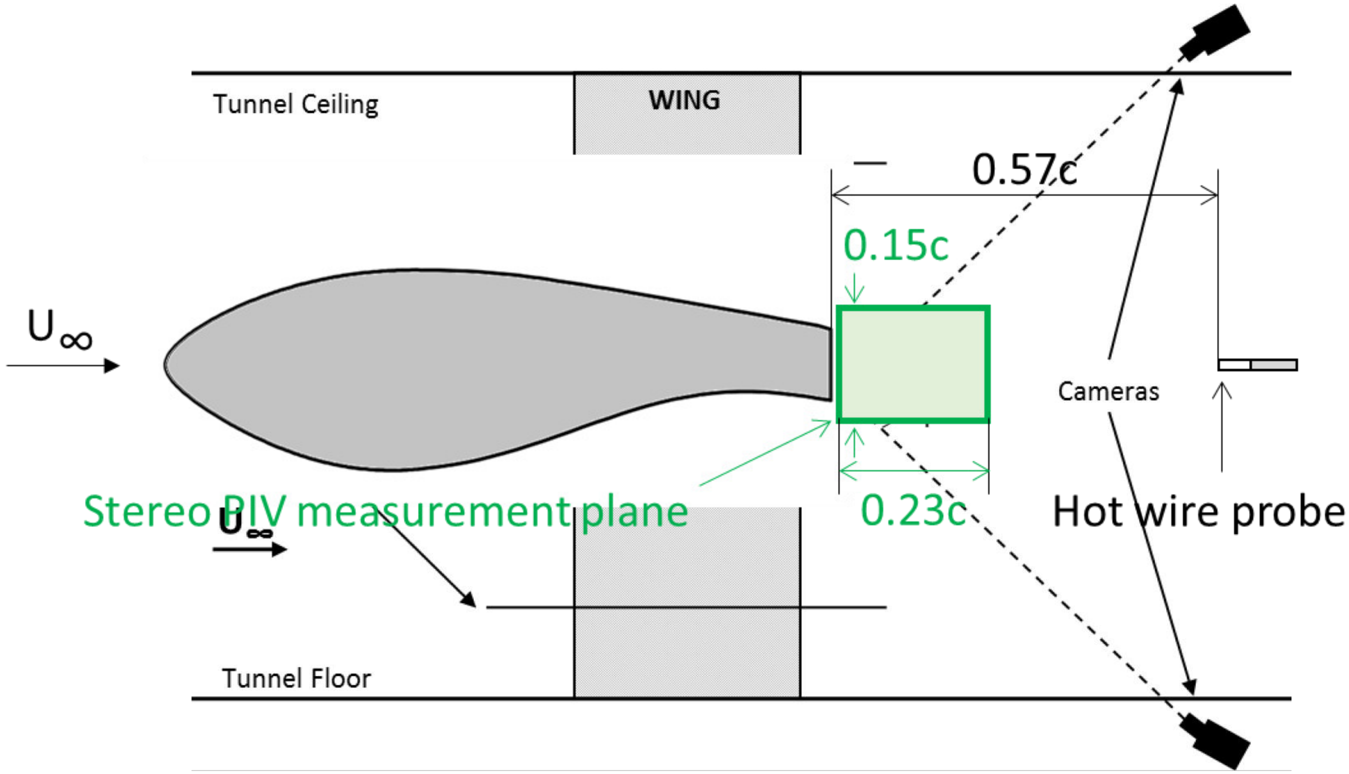


Challenges

3D, unsteady and unstable **separated flow**

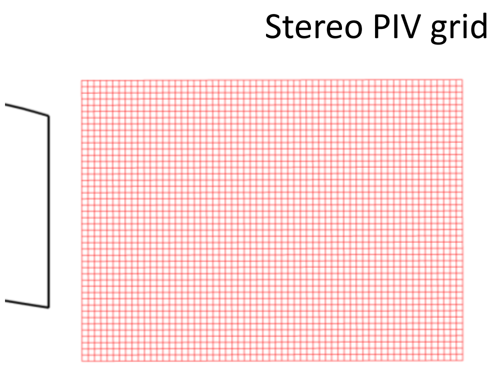
U_∞

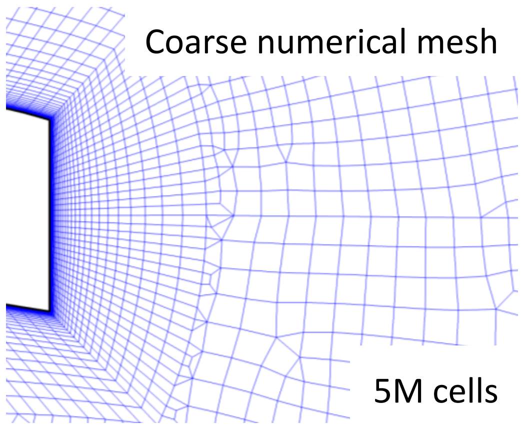
Experimental Set-up

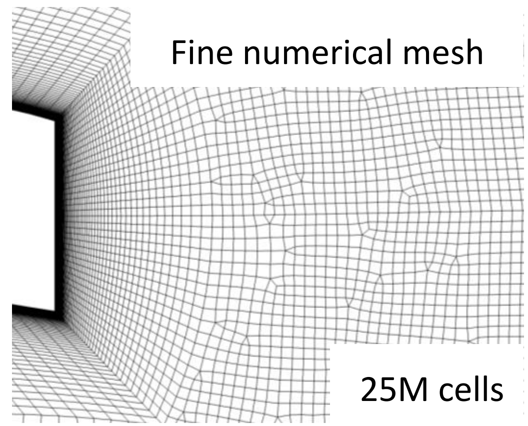


- Pressure measurements on wing surface and trailing edge
- Pressure wake rake
- Stereo PIV and hot wire measurements in the wake
- Re = 1.5M, AR = 2.0
- TE thickness = 0.1c

Numerical Set-up



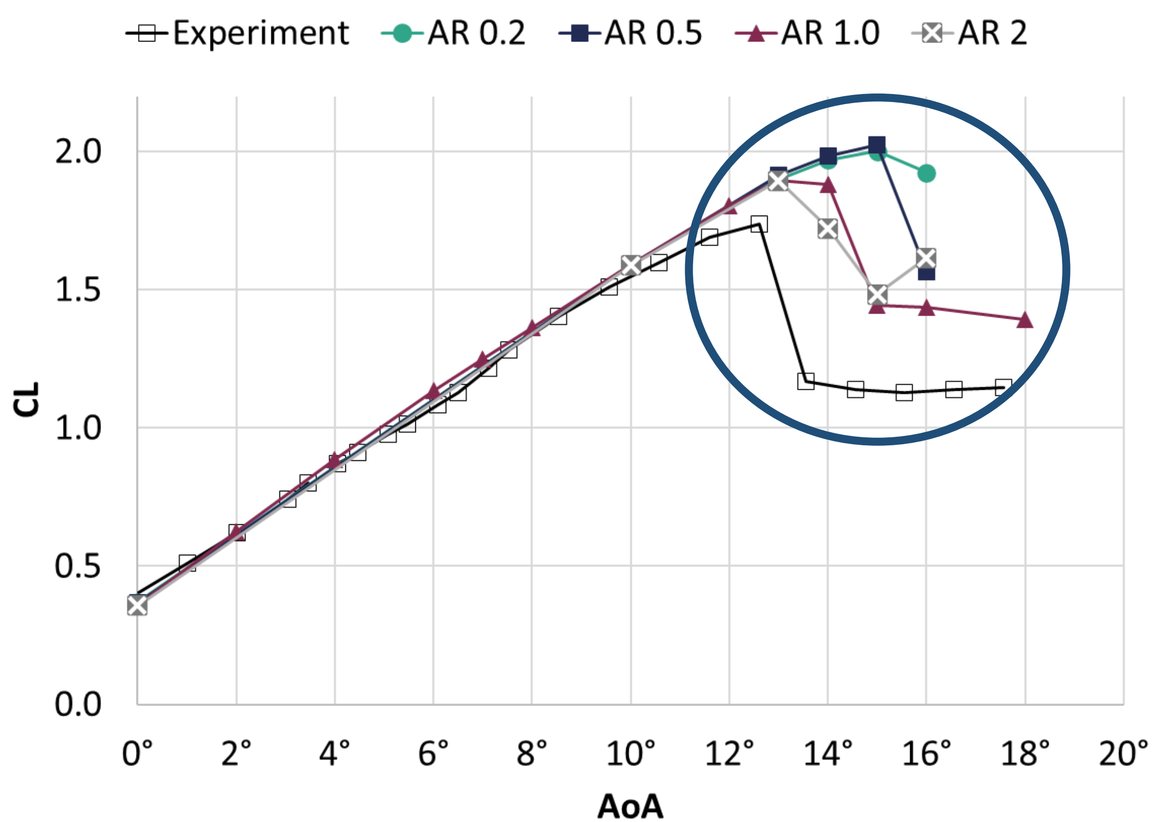




- In-house solver, **MaPFlow**
- Unsteady RANS and IDDES simulations **on the same grid**
- **SA model**
- Farfield at **100 chords**
- **Symmetry conditions** at the side boundaries
- Varying computational domain Aspect Ratio

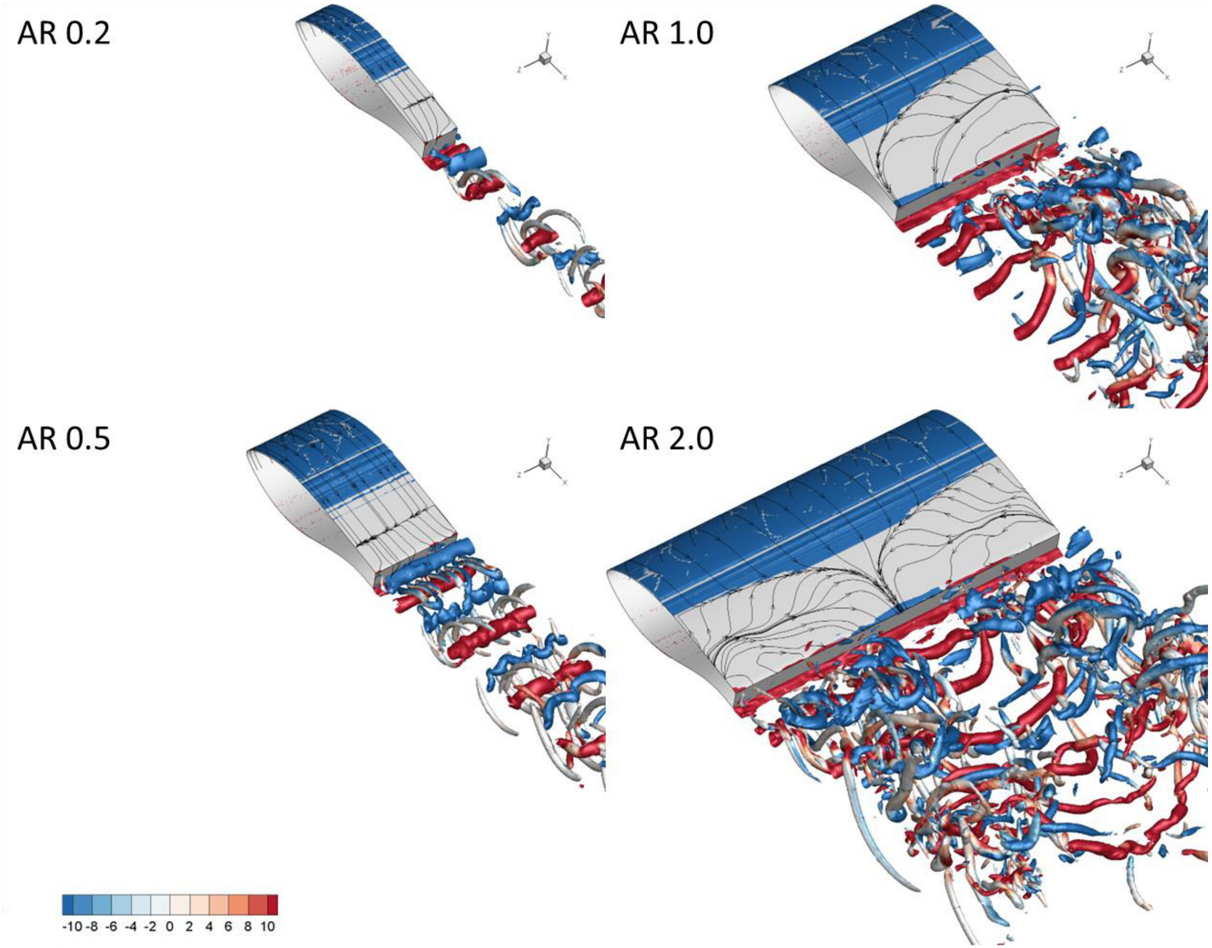
Results – AR study: How much is enough?

Forces – Lift: $\boldsymbol{AR > 0.5}$ to capture formation of 3D separated flow (Stall Cells)



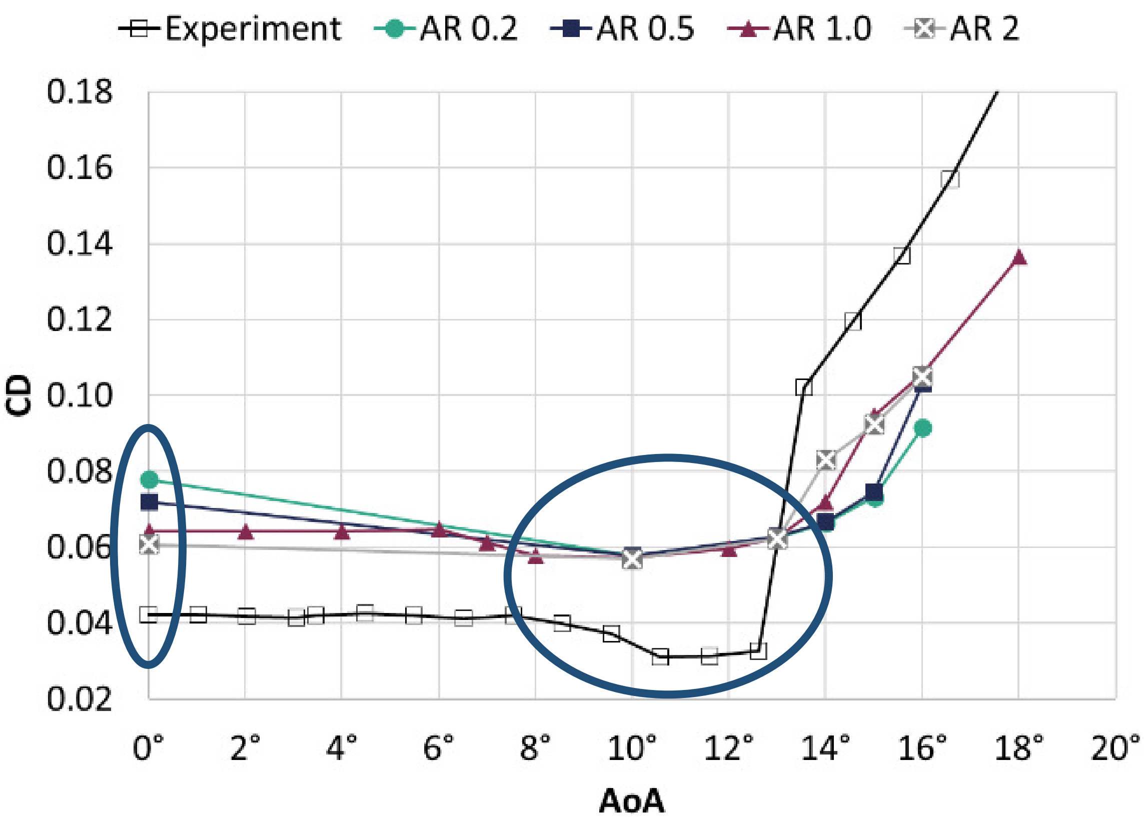
Results – AR study: How much is enough?

Forces – Lift: $AR > 0.5$ to capture formation of 3D separated flow (Stall Cells)



Results – AR study: How much is enough?

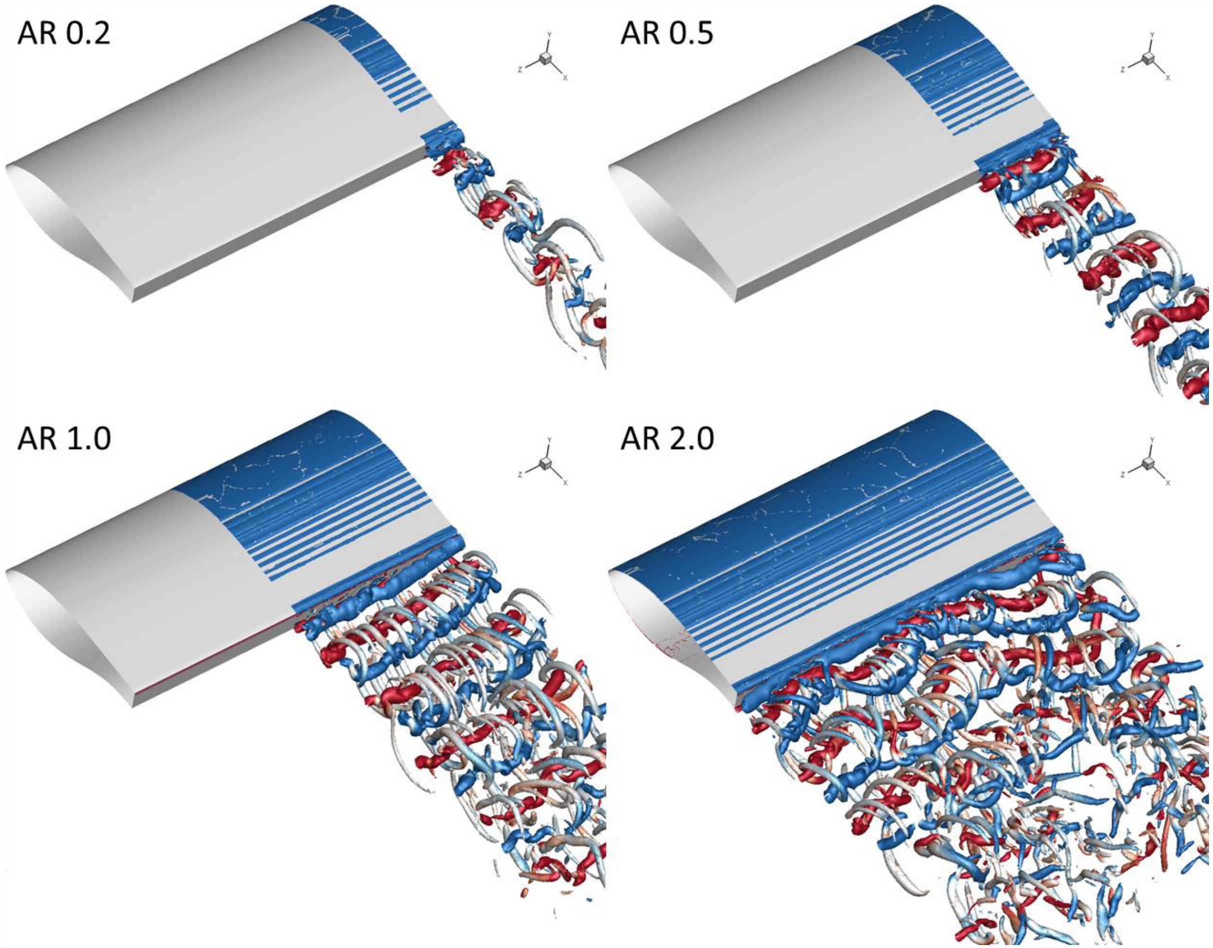
Forces – Drag: The higher the better, still quite far off



What causes the drag reduction at high AoA?

Results – AR study: How much is enough?

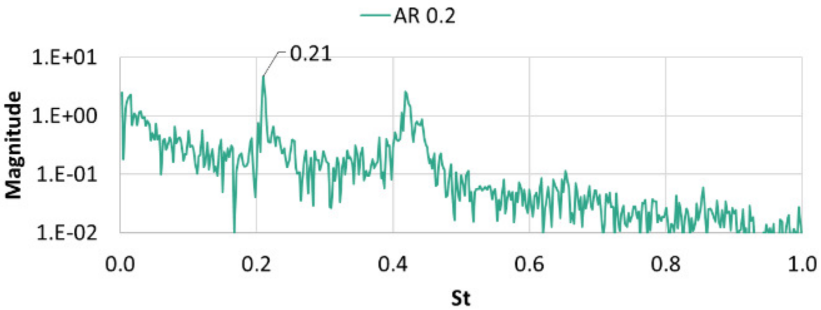
Forces – Drag: $AR \geq 1$ for oblique shedding, vortex dislocations etc

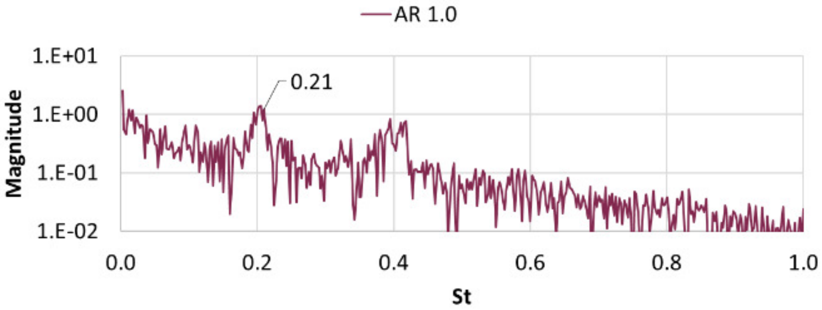


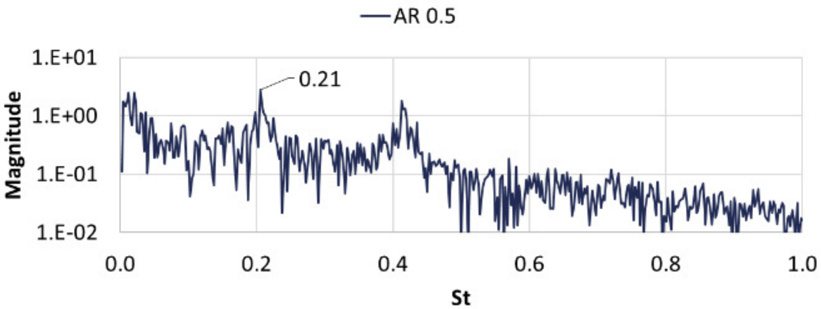
Results – AR study: How much is enough?

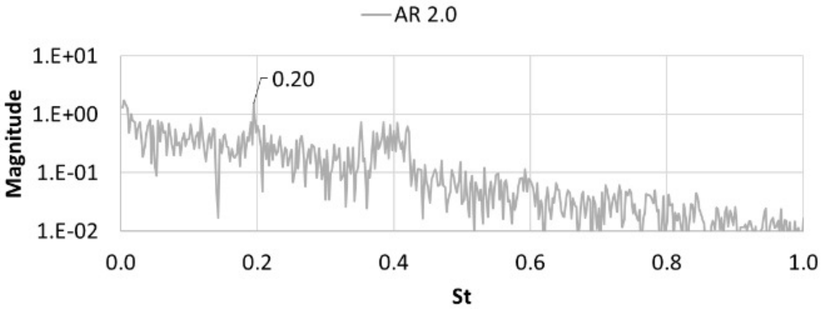
Vortex Shedding:

- Dominant vortex shedding frequency does not depend on AR.
- Predictions ($St = 0.21$) a bit lower than the experiment ($St = 0.24$)



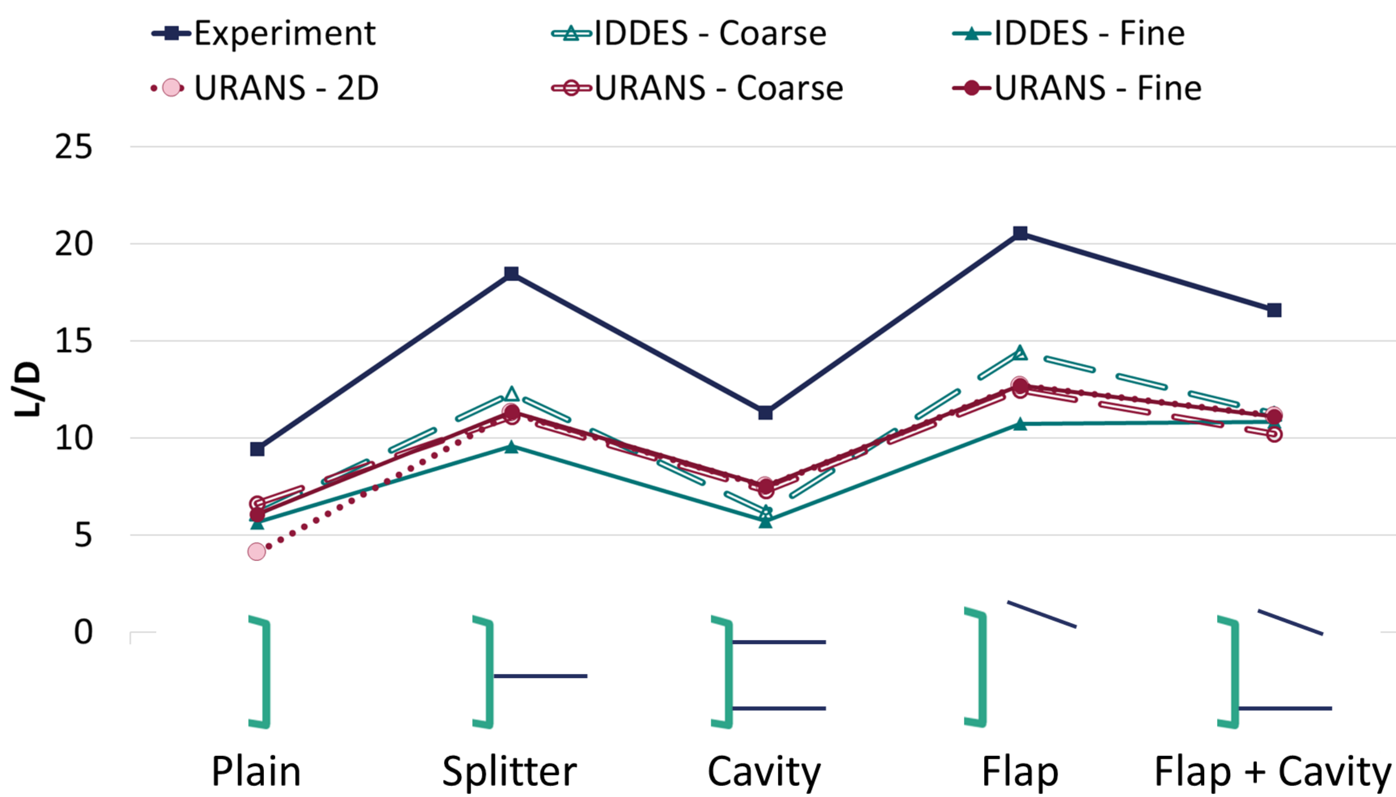






Results – Is URANS at all useful?

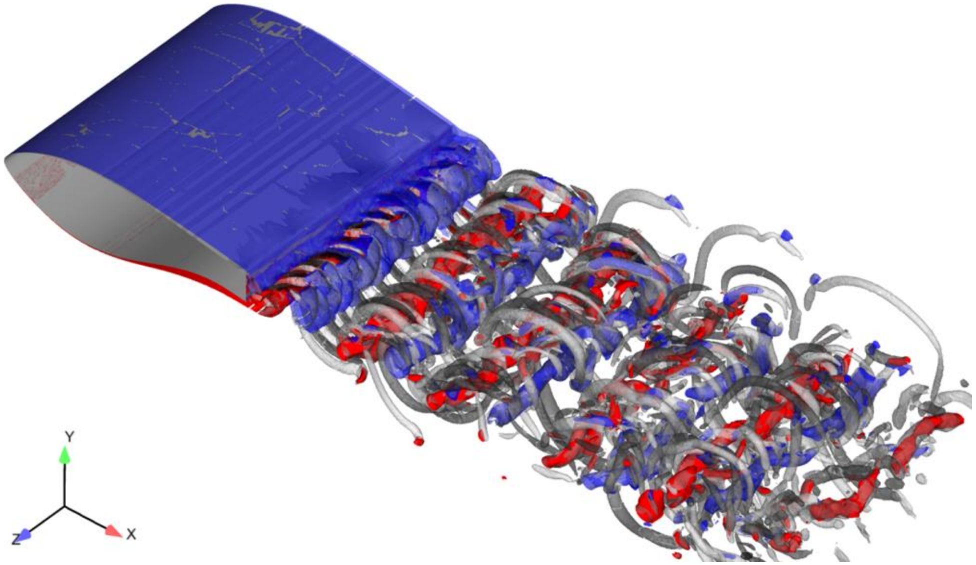
- Yes, for trends



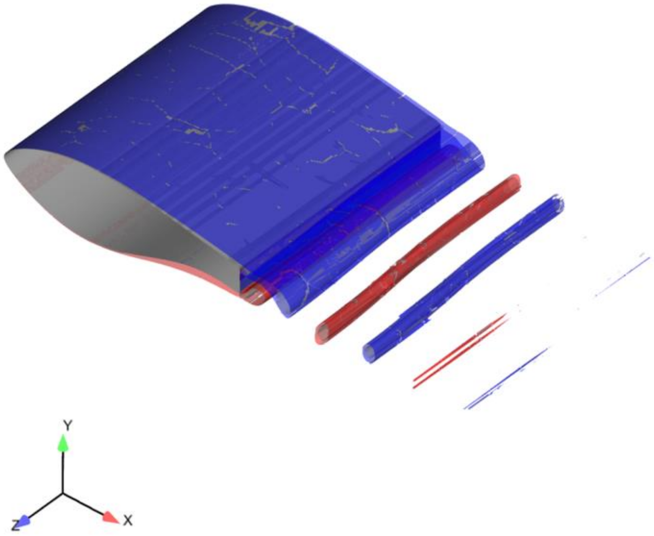
Results – Is URANS at all useful?

- Not for wake studies

IDDES



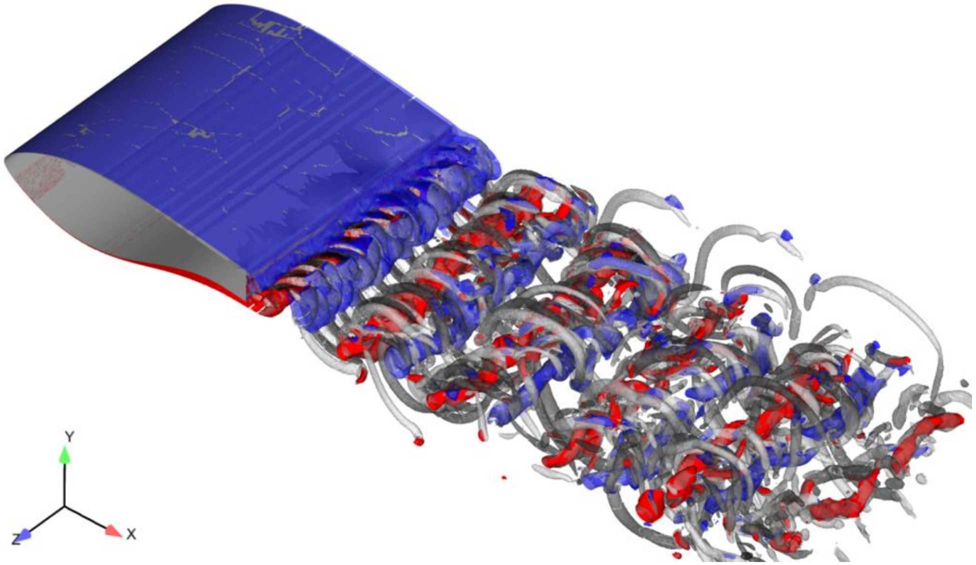
URANS



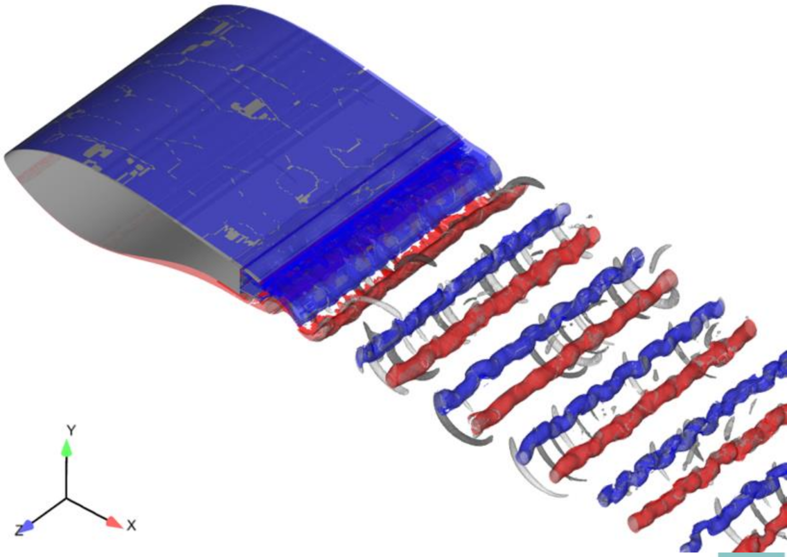
Results – What does IDDES reveal for the drag reduction mechanism?

- Altering the wake structure leads to significant drag reductions

No Control



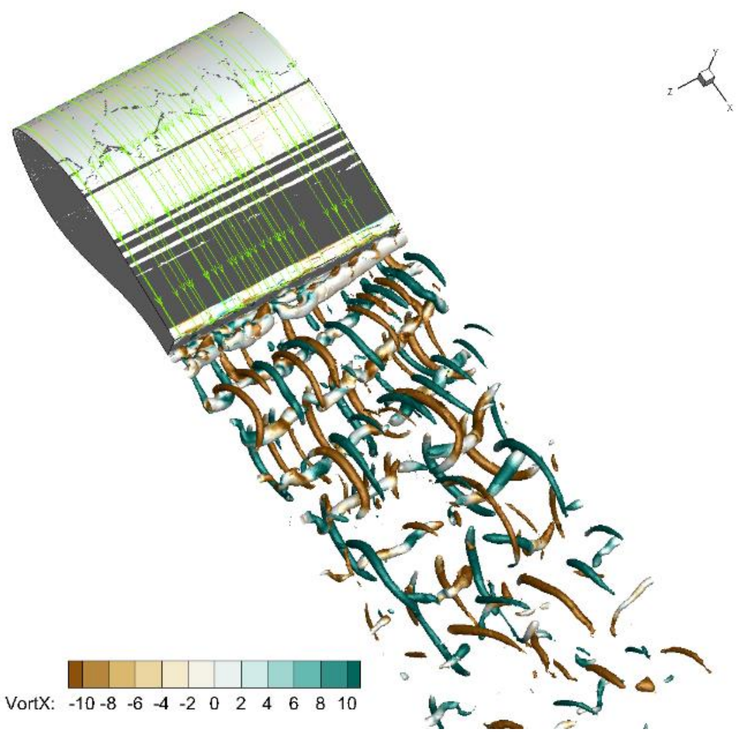
New Device



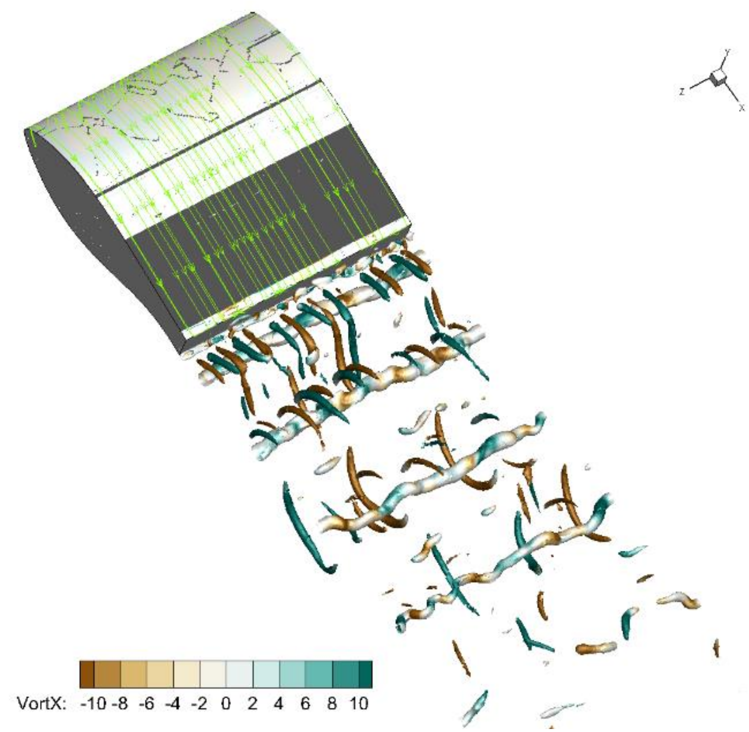
Results – What causes the drag reduction at high AoA?

Secondary instability in the wake changes at high AoA.

0deg – $Cd \cong 0.04$



12deg – $Cd \cong 0.03$



Thank you!

Questions?